Crime Mapping Using Geographical Information System Techniques

By

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DECLARATION

"This dissertation has been composed by me. It has not been accepted in any previous application for a degree, and the work of which it is a record has been done by me. All quotations have been distinguished by quotation marks and sources of information have been acknowledged in the text and cited in the list of references."

Signed: Bader Almutairi

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Abstract

The study aimed to determine the efficiency of GIS in analysing and visualizing both temporal and spatial patterns of reported crimes and crime rates in Bedford, UK, from January 2013 to December 2015. It combined the spatial models for wards in Bedford with the help of GIS techniques with statistical methods. During the study, cluster analysis was conducted while considering seasonal variations for the three major types of crime (antisocial behaviour, criminal damage and arson, and violence and sexual offences). These three types of crime were selected because of their higher incidence in Bedford during the period of January 2013 to December 2015. The study also included consideration of certain geographic and demographic factors. The temporal analysis revealed that the incidence of crime is highest during the summer and spring seasons and low in winter and autumn. During spatial analyses, the positioning of crime hotspots changed with respect to wards, but remained higher in the central areas where average population is moderate. Mapping of crime clusters from 2013 to 2015 provided an illustrative overview of how crime expanded in 2015 as population increased and of the relative patterns of fluctuation with every season. This implies that spatial distribution of crime is related to the occurrence of crime hotspots. Using statistical software to analyse the data for crime and demographic factors led to the conclusion that there was insignificant association between population and crime distribution. However, the results show a strong association between crime rate and season.

The study supports the use of GIS as a major decision support tool for investigating crime patterns. The study recommends the use of GIS techniques to create models that predict the areas where crimes will occur.

Crime Mapping Using Geographical Information System Techniques

CHAPTER 1: INTRODUCTION

Research Background

In a globalized world, crime has become more prevalent in society. This has significantly increased the need for improved information systems to tackle crime worldwide. In the past, pin maps were the most popular method of determining which places had high concentrations of crime events; however, they did not provide comprehensive and accurate data regarding crime scenarios (Santos, 2012). In light of the literature, a solution was proposed in the form of geographic information systems (GIS), for their efficient utilization of information technology, which makes them an effective and efficient method of analysing and visualizing criminal activity (Hill & Paynich, 2013). According to Hoover et al. (2010), GIS have proven to be a valuable and an effective technique for calculating the spatial distribution of crime patterns. More importantly, it has been found that this technique can handle significant volumes of data in a more efficient manner than earlier techniques and methods used by law enforcement agencies. In this regard, Goldsmith et al. (1999) suggested that GIS have provided law enforcement agencies with the ability to save time and effort during the integration of data, while providing analysts with the ability to look at the elements of criminal activity including the environment, types of crime and characteristics of crimes.

Geographic Information Systems (GIS)

Geographic information systems have been increasing in popularity as a technique for crime analysis. With advancements in technology, the advent of such a system has made crime mapping easier than before (Chang, 2015). Crime mapping refers to visualizing, analysing and mapping criminal incident patterns. GIS allow the identification of crime hotspots in the mapping

process. They further help to analyse and measure the trends and patterns of a potential crime scene.

According to Ferreira et al. (2012), statistics serve as a significant tool for crime analysis. GIS help present the statistics in an easy-to-understand and comprehensive form by streamlining the dataset available to law enforcement agencies. GIS also allow crime analysts to overlay other datasets, for example, census demographics or location maps, to track crime and produce density maps (Erdogan, et al., 2008). This helps law enforcement agencies to devise incident-related strategies in order to deal with the problems at hand. This contemporary technique has also enabled law enforcement agencies to refine strategies for dispatching police officers to emergency areas.

The Study Area

Bedford is the county town and administrative centre of Bedfordshire (Figure 1). Bedford lies in the South East Midlands, in central part of the UK, close to London. The latitude and longitude of Bedford City Centre are 52.136436 and -0.460739 respectively.

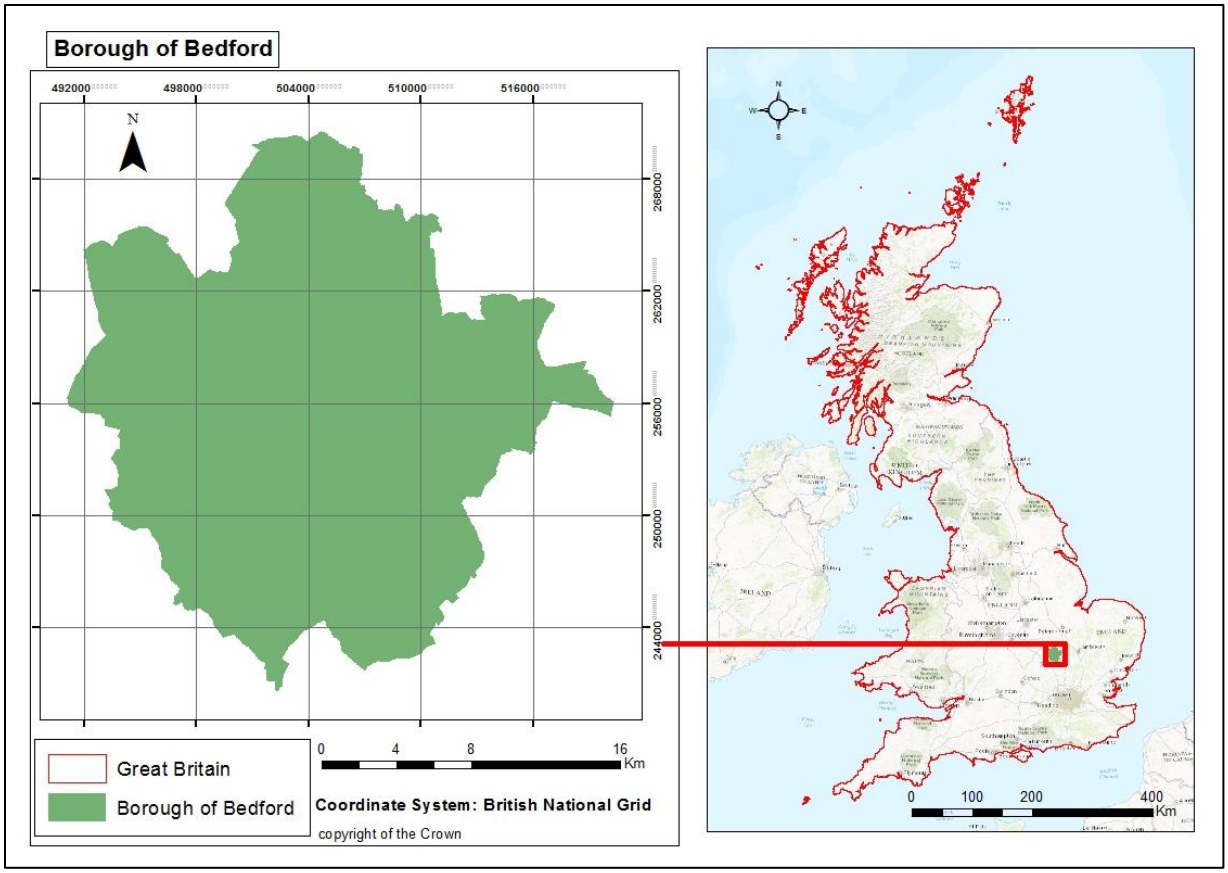


Figure 1: Borough of Bedford (Copyright © Crown and database rights 2011 Ordnance Survey).

According to the 2014 Census, the population of Bedford City in 2014 was 102,410 (Office of National Statistics, 2014). It covers approximately 29.7 km^2 and contains 14 wards (Figure 2 and table 1). The urban areas are densely populated; per annum, the population increases by around 2%. Therefore, it is one of the fastest-growing areas in the United Kingdom (Conniff & Hitchcock, 2012). Bedford has also considerable ethnic diversity, with more than 100 different ethnic groups living within its boundaries.

Table 1: Bedford wards (Copyright © 2016 Bedford Borough Council).

1- Brickhill	2- Castle
3- Cauldwell	4- De Parys
5- Goldington	6- Harpur

7- Kempston Central and East	8- Kempston North
9- Kempston South	10- Kempston West
11- Kingsbrook	12- Newnham
13- Putnoe	14- Queens Park

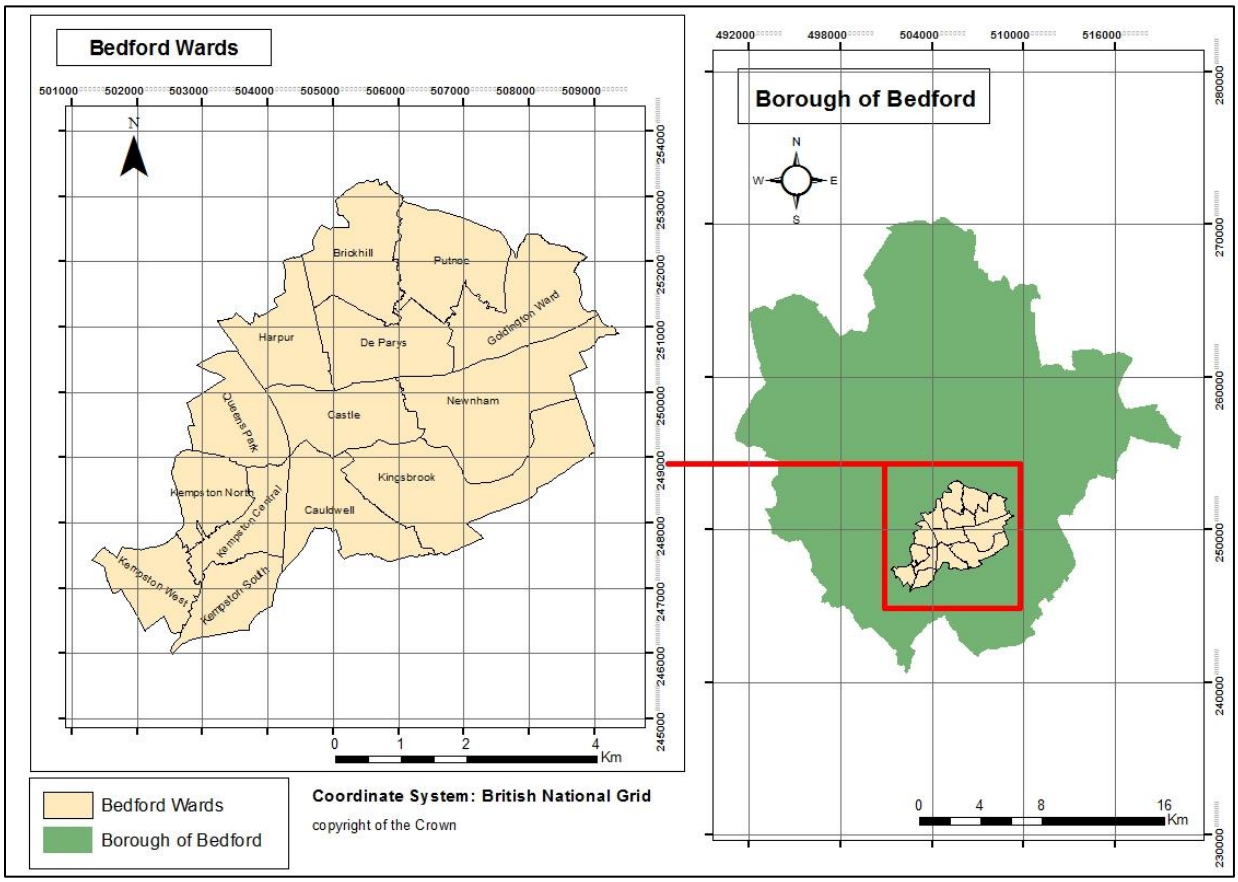


Figure 2: Bedford wards (Copyright © Crown and 2016 Bedford Borough Council).

Statement of the Problem

Bedford represents one of the largest areas in terms of population and is considered to have a high level of crime, based on national figures (Leach & Grant, 2015). It has been found that approximately 50% of recorded incidents relate to antisocial behaviour (Thompson, 2012). In 2013, the average number of crimes per 100 residents in the UK was 5.02, whereas Bedford's average had decreased by -1.61 as compared to previous years (Figure 3).

Figure 3 Antisocial behaviour in 2013 (Source: Mirror.co.uk, 2014).

Taking this into account, police patrols have played an influential role in noting antisocial behaviour and dealing with it in the most appropriate manner. In light of the level of criminal activity in Bedford, the police have indicated that the crime rate in Bedford is higher than the average across similar areas. In the following figure, Bedford is between the red and green lines, which represent the difference in crime rate from the average. This figure illustrates that the average crime rate is 60 per 1,000 populations, as represented by the blue line on the graph. In particular, if an area lies between the red and green line, the crime rate is considered to be normal for the group, whereas an area that lies above the red line is considered to have a higher crime rate. Bedford lies above the red line, which represents the upper bound of police-recorded crimes per 1,000 individuals (Figure 4).

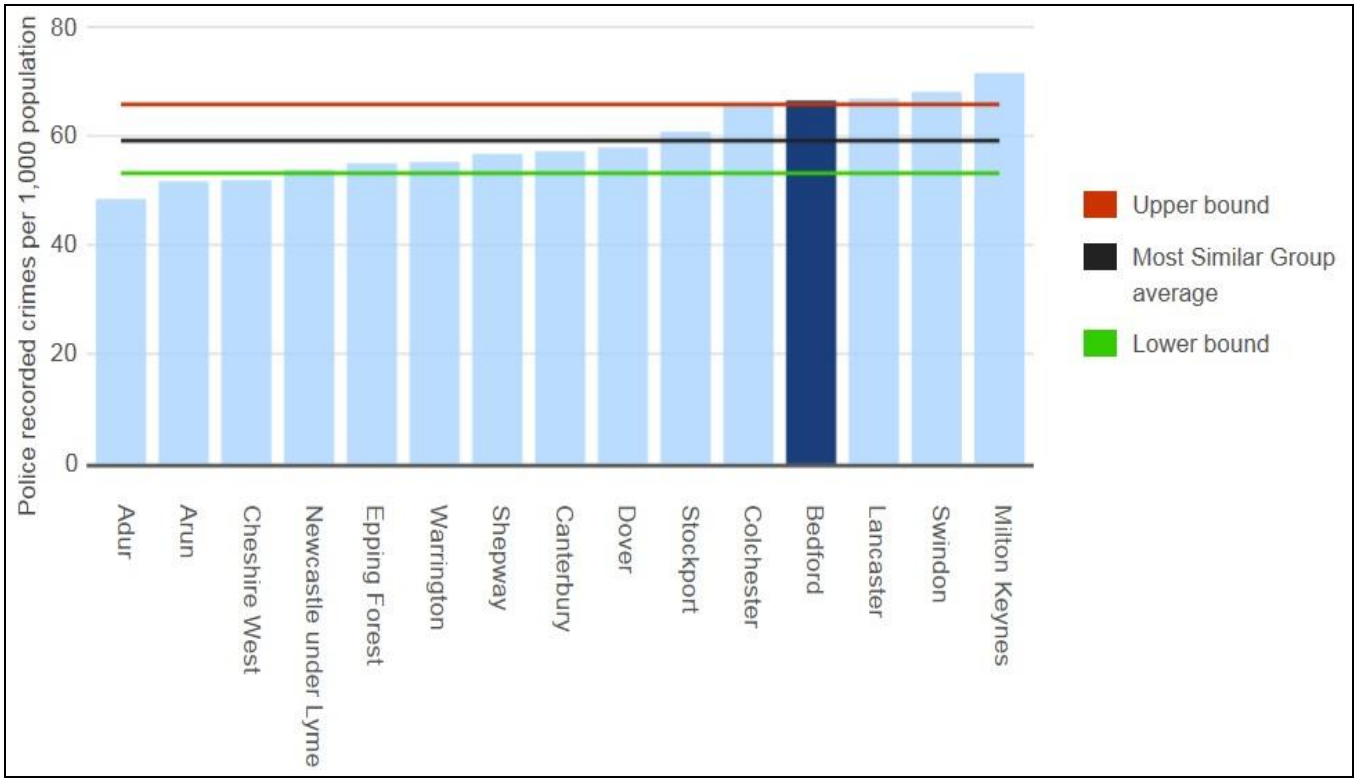


Figure 4 Crime rate in Bedford (Source: Police UK, 2016).

Accordingly, it is helpful to analyse the spatial distribution of crime in this area using GIS techniques. These techniques assist in determining crime hotspots in Bedford and the nature and type of crimes therein. By using these techniques, law enforcers will be able to detect which places need extensive observation and thus reduce the crime rate. In addition, GIS techniques enhance the ability to predict future crimes, which assists in preventing them (Chainey & Ratcliffe, 2013).

Research Aims and Objectives

The purpose of this research is to determine the efficiency of GIS in terms of analysing and visualizing both temporal and spatial patterns of reported crimes and crime rates in Bedford from January 2013 to December 2015. This study has focused on detecting and determining the most common types of crime, which are antisocial behaviour, violence and sexual offences, and criminal damage. There are many other crimes that occur in Bedford, but these three types of crime are the most prevalent. This requires the identification of the hotspots and clusters of criminal activity

with respect to type, size and distribution. Taking this into account, the researcher has relied on the use of GIS and spatial statistics for analysis of crime activities.

The research objectives of this paper are as follows:

- To determine the efficiency of GIS in crime analysis
- To investigate the geographical elements that have an influence on criminal activity in Bedford
- To determine the most common types of crime committed and their underlying factors.

Research Questions

The research questions surrounding the study are as follows:

- What are the most prominent types of crime in Bedford and where is each type prevalent?
- What is the spatial distribution of crime in Bedford?
- What is the temporal distribution of crime in Bedford?
- What is the relation between crime and demographic factors?

Significance of the Research

The significance of the research is twofold. Firstly, the research will help to develop an understanding of the connection between crime and demographic factors. Moreover, this research study will help in addressing frequently asked questions regarding the occurrence of crime; the use of GIS techniques has allowed the researcher to address these questions. Secondly, the research will provide the academic community with an understanding of the usage and importance of GIS techniques for the reduction of criminal activity in the locality.

Research studies conducted in Bedford regarding crime are scarce; therefore, the researcher has considered addressing the issue through the use of GIS techniques.

Procedural Definitions of the Concepts

Some of the key concepts of the research study are briefly described below:

Spatial Distribution of Crime:

According to Bogue (1969), the term refers to the spread of crime in a region. In particular, the term focuses on crime patterns, while identifying the underlying factors and causes of specific patterns.

Spatial Relationship:

The term spatial relationship refers to the interaction and relationship among crimes and the region.

Size:

The magnitude of the phenomenon is referred to as its size, i.e. the number of incidents during a particular time period.

Summary of the Chapter

This chapter discussed crime analysis and the use of GIS techniques in the technologically advanced era. Law enforcement agencies have developed reliance on the use of GIS techniques to analyse and visualize criminal activity. Since this is the most effective and efficient technique, it has been widely accepted and acknowledged by law enforcement agencies worldwide. The chapter also included the statement of the research problem, the aim and the objectives, followed by the significance of the study.

CHAPTER 2: LITERATURE REVIEW

The main goal of crime analysis using GIS is to create and identify the data required to support decision-makers regarding the distribution of police resources and the occurrence of crime activities to reduce and prevent criminal activity. Therefore, GIS experts and crime analysts are important in providing significant information for decision-makers. Moreover, crime analyses can be used to evaluate and enhance the plans of police forces to deal with crime patterns and help police to understand criminal activity.

This chapter will discuss the reasons for crime in light of a number of theories and reviews. Many studies have examined crime analysis and crime mapping using GIS techniques, because it is considered a valuable tool for police- and community-based studies (Chainey & Ratcliffe, 2013). The crime history of Bedford will be demonstrated in this chapter as general survey required in this study.

Reasons for Crime

According to Eck and Weisburd (2015), in order to measure crime, the initial step required is to understand what the crime is, why it occurs, the core reason for it, and what the impacts are on individuals and society. Many different theories focus on why a person chooses to risk their life and take on a criminal role. It is necessary to look into theories by different authors to understand the core reasons for criminal activity (Alper & Chappell, 2012). According to Farrington (2014), there are four main theories that can be used to identify the purpose behind a criminal act:

Psychological Theory

- The feeling of pleasure or hedonism (the main triggering factor).
- Offending through the sense of right and wrong (An inner self-consciousness).

- The way a child is raised by parents, as harsh methods leave an imprint on and aggression within the child.
- Lowered potential to be influenced by the consequences of offending (Farrington, 2014). For example, antisocial behaviour is learned as parents tend to be antisocial influences.

Sociological Theory

A- Social learning theory

This theory helps us understand why a person would engage in crime; if they are exposed to criminal models and they are taught the benefits of criminal activity by their peers, they are forced to believe in it (Akers, 2013).

B- Control theory

According to Bossler and Burruss, some people firmly believe that there is no harm in committing a crime as everybody has their needs and they can easily be fulfilled, met and satisfied by criminal acts. These people argue that when an opportunity presents itself, it is easier to deviate from the right track and commit crimes than to actually work and make money legally (Bossler & Burruss, 2011).

C- Strain theory

This theory explains that a person who is undergoing some kind of stress and strain might be attracted to committing a crime; they might also do it to escape parental restriction or financial issues, or perhaps to take revenge on someone (Walters, 2011).

Biological Theory

Criminal behaviour can be understood in light of certain social and biological theories. The social factors refer to surrounding influences, whereas biological factors include physiological,

neurological, biochemical and genetic factors. Unlike social factors, genetic factors are inherited by individuals (Smart, 2013).

Conflict Theory

This theory states that because there are two classifications in the world, the rich and poor, criminal law and the justice system work on behalf of the two classifications. This theory proposes that the core issues that lead to crime are economic and social forces (Brown & Esbensen, 2010) and discusses how minor crimes such as mobile snatching and other street crimes are handled very severely while large-scale business and financial crimes are treated more leniently.

Crime Mapping

Crime mapping is used by authorities in law enforcement organizations to analyse crime locations. Crime mapping is the main component of the CompStat policing strategy (short for COMPuter STATistics) and crime analysis. This policy was developed in the 1980s when police forces began using computers to target their efforts to combat subway crime in New York City. Crime analysts, in the technologically advanced era, are provided with an opportunity to analyse crimes and related issues through the use of graphic representation. More simply, an understanding of the location and the underlying reasons for crime has significantly improved attempts made towards fighting crime (Eck, et al., 2005). Moreover, it has been found that mapping crime can play an influential role in helping law enforcement agencies to protect and serve citizens in a more effective manner. Simple maps have frequently been used by law enforcement agencies to determine concentrations of crime, which has helped in targeting patrols. More importantly, law enforcement agencies can use more complex and sophisticated maps for observing the trends and patterns of criminal activity to solve criminal cases (Ratcliffe, 2010).

Despite the benefits of crime mapping technology, the way police departments utilize it is not straightforward. The learning curve can be underestimated and a lot of hard work and planning is required to integrate mapping into departments. Studies conducted by Rich (2012) and Mamalian and LaVigne (1999) of the National Institute of Justice in Washington, DC prove that many sectors are, by means of crime mapping, producing hotspot maps and computerized pin maps. For more modern analysis, some information is needed from geographic information systems (GIS) and cartography as hotspot analysis and pin maps are becoming outdated. It is possible that, due to the complexity of the latest technology, most departments might find it difficult or impractical to adopt these methods. The subsequent steps of implementation and methodological development are daunting and should begin naturally with, first, revisiting the suggested crime classification and mapping it to current (or not-as-yet created) data sources that might supply the requisite information.

The application of GIS technology has been discussed by Canter et al. (1997) with the police of Baltimore County, Maryland, U.S. They discussed methods of enhancing policies of interdiction and analysis of crime by utilizing GIS applications and evaluation of the accuracy of preventive policies. The strategy discussed in the above-mentioned study was broadly established and used by police departments in the area of study as it has been considered the most efficient of the previous techniques "The pin map technique" and developed an advanced digital map technology. Canter et al.'s study plays a significant role in demonstrating and understanding criminal activity from the perspective of geography (Hammond & Youngs, 2011).

According to Canter (2000), geographical profiling relies on trustworthy attempts to examine different sources of geographic information to create an image of spatial interaction between the victims and the offenders in criminal activity. Since this shows a creative application

of environmental criminology theory, hopefully geographic profiling would become a good-quality investigative tool for tackling serious crimes. Geographic profiling could also prove beneficial for addressing single crimes but Canter's study was purely based on serial crimes.

It has been established by research that crime hotspots can be detected in a more effective and valuable manner by using the clustering investigation technology in software packages such as SAS and CrimeSTAT (Murray & Grubesic, 2001). Areas with elevated levels of crime can easily be located using the technique of "clustering analysis". Also, the challenge in utilizing this approach was related to an accurate number of clusters creates an importance of the individual clusters (individual clusters aim to create a group of objects where properties are more similar to each other than when compared with other objects belonging to a different group).

The cost of crime mapping is not an obstacle for most police forces as basic mapping programs are not expensive. According to Mamalian and LaVigne (1999), a survey carried out in 1997 on law enforcement in the USA showed that one department had crime mapping capability, 38% had customized software, 88% used commercially accessible software packages, 82% used the Internet, and 16% used GPS to support their actions. 91% of the agencies reported mapping offence information and 52% reported recording vehicle recovery information.

Displaying Spatial and Temporal Patterns of Events

In light of the literature, it has been suggested that digital maps enable law enforcement agencies to visualize an entire crime scenario in the most effective and convenient manner (Wallace, 2009; Roth et al, 2013; Boondao & Tripathi, 2007). This implies that law enforcement agencies can use digital maps to establish the location of crimes and arrests (Chainey, et al., 2008). More importantly, it has been found that displaying spatial patterns of events has made it significantly easier to view the criminal activity in an area, instead of searching for criminal

activity in the locality through a list of events. Considering this, it has been argued that the use of GIS techniques has provided an opportunity to use the maps in various ways for conveying information at the right time and place. Likewise, the location of a crime can be symbolized through the use of GIS on a daily, weekly and monthly basis, where information related to different types of crimes can be visualized and analysed (Lockyer-Cotter, 2013).

According to Diggle (2013), spatio-temporal pattern analysis refers to crime analysis. Spatio-temporal pattern analysis extracts information for crime analysts from time- and geo-referenced statistics. Several types of spatio-temporal crime patterns need to be observed in order to gain appropriate information. The main motive of spatio-temporal crime pattern analysis is to gather data to further underline the root causes of crime. On the other hand, according to Ahmadi (2003), enabling officers to picture spatial patterns of criminal occasions has meant that practitioners have started to become conscious of the benefits of maps as compared to printouts. It is much easier to discern spatial patterns than a difficult point map.

Integrate Community Characteristics

The use of GIS provides law enforcement agencies with a unique opportunity to determine the relationship between community characteristics (i.e. educational establishments, red light areas, alcohol-permitted locations etc.) and crimes (Wang, 2005). For instance, the use of crime mapping through the use of GIS can display the locations where alcohol is sold, while determining the rise of crime in such areas.

Production of Thematic Maps

Crime mapping also allows the production of maps at the geographic level, which plays an influential role in analysing crime patterns and criminal activity (Maantay & Ziegler, 2006). At the same time, it provides the ability to classify the area according to the crime rate during a

specific time frame. Likewise, thematic maps have often been used to demonstrate the change in crime rate in a specific region (Maantay & Ziegler, 2006).

Intelligence-led Policing (ILP)

The tactical operation of police resources has been discussed in the results of Dyras and Serafin-Rek (2005) with the objective of recognizing areas with higher levels of offences to establish efficient analytical models and to develop maps of the research region. It has been documented by the authors that many services provided by the police and communities have been involved in this advanced technology, such as intelligence-led policing.

ILP is the process of fighting crime by means of efficient detection and intelligence assembly. It also possesses the capability to be the most significant modification of law implemented in the 21st century. Intelligence within the enforcement of the law means different things to different people, but the suggestion that has been derived from this approach is that the police can have a significant influence on crime. It has been determined that crime analysis can be utilized to arrest, influence or give evidence against a criminal. The law of criminal enforcement can also be supported by superior intelligence and also found to be meaningful in reducing or preventing crime. This technological progress appears at the right time with an enhancement in the solutions of law enforcement at restricted level. ILP methods have been considered as an efficient strategy to support the work of police departments.

Types of Criminal Intelligence

Tactical Intelligence

This is the most familiar type of criminal intelligence and it is used in many operations all over the world. This category focuses on the analytical process of providing the right information to the right department, which eventually helps operational personnel in the identification of specific and immediate crime patterns, trends, sprees and hotspots (Johnson, 2000). This has been proven to be an effective approach in investigating leads and clearing up cases at a fundamental level.

Operational intelligence

Operational intelligence is another type of criminal intelligence that is used in the analysis of crime. It is introduced at a wider organizational stage (Maguire & John, 2006). Operational intelligence is the formation of intelligence creation, in which support is provided to regional commanders and managers of regional operations in designing crime reduction activity and organizing resources to attain operational objectives (Maguire & John, 2006). Operational intelligence helps decision-makers to evaluate which of the criminal groups are most susceptible to enforcement or which regions of a city require more resources.

Strategic Intelligence

This is the third type of criminal intelligence used in crime analysis and its objective is to provide understanding and insight into models of criminal behaviour and the criminal environment. Its basic aim is to make intelligence proactive and future-oriented. This category is only concerned with the long-term issues and challenges that may result from an increase in the crime rate

(Johnson, 2000). It is most concerned with the preparation of statistical summaries related to crimes, followed by the acquisition and allocation of resources.

Strategic intelligence is used by top-level managers and executives with responsibility for planning the designs that influence the environment (Maguire & John, 2006). The outcomes achieved by good strategic analysis not only benefit the police but also impact on other organizations that are involved in the maintenance of peace and justice.

Crime Analysis

The term crime analysis refers to the systematic and analytical process of providing timely and accurate data and information regarding the patterns and trends of crime, which eventually helps administrative and operational personnel to plan and deploy resources to prevent and/or suppress criminal activity (Rybarczyk & Wu, 2010). At the same time, it also supports the investigation process to resolve cases in the most appropriate manner (Fisher & Fisher, 2012). Crime analysis has played an important role in a number of department functions such as special operations, investigations, patrol deployments, crime prevention, planning and research, and tactical units.

According to Ahmed and Salihu (2013), the application of geographical data systems and spatial records of crime features has played a significant role in the investigation of crime hotspots in Dala City in Nigeria. It was established that the rate of crime was greater in the external areas of the city than in the interior of the city. Different surveys were conducted and discussed widely in this study, and these surveys showed that the ratio of crime increased gradually and became higher in 2010, when more hotspots were observed in the outer areas of the city, whereas no crime was detected near the police stations. It was also recognized that for crime detection, static maps were found to be more precise and efficient than animated maps.

Crime in Bedford

According to Marlow (2014), Bedford is a highly densely populated area and there is a big increase in crime rates from rural to urban areas. According to the Mirror's Crime Database (2014), Bedford is considered to have a high crime level. Information and statistics for crime in Bedford are as follows:

Antisocial Behaviour

Antisocial behaviour is reckless behaviour intended to harm any person or property (Jones & Sagar, 2001). In Bedford, antisocial crime is one of the major problems faced by police and the increasing incidence of this kind of crime has become one of the challenges faced by local police. The statistics for antisocial behaviour in Bedford between January 2013 and December 2015 showed an increase in antisocial behaviour from 315 to 372, with wide fluctuations over the period. The overall UK average for crime in 2013 was 5.02 crimes per 100 residents while the overall average in Bedford was 3.56 crimes per 100 residents, and it was ranked as 207th of 348 in terms of preferred areas in which to live according to crime rate (Figure 5) (MIRROR.CO.UK, 2014).

	Area	Crime rate	Rank
Best Area	Isles of Scilly	0.44/100 residents	1
Your Area	**Bedford**	**3.56/100 residents**	**207**
Worst Area	City of London	13.77/100 residents	348

Figure 5: Antisocial behaviour in 2013 (MIRROR.CO.UK, 2014).

Criminal Damage and Arson

The category of criminal damage and arson in Bedford was ranked second after antisocial behaviour in 2013. According to the Criminal Damage Act (1971), it refers to the intentional act of destroying or harming someone else's property such as house or vehicle. Any individual who destroys someone else's property without a lawful excuse or who shows recklessness should be held guilty of an offence. In Bedford, the rate of this kind of criminal activity has increased, according to the latest studies; in 2013, cases of criminal damage and arson in Bedford totalled 1,063, whereas they rose to 3,359 by the end of 2015 (Figure 6).

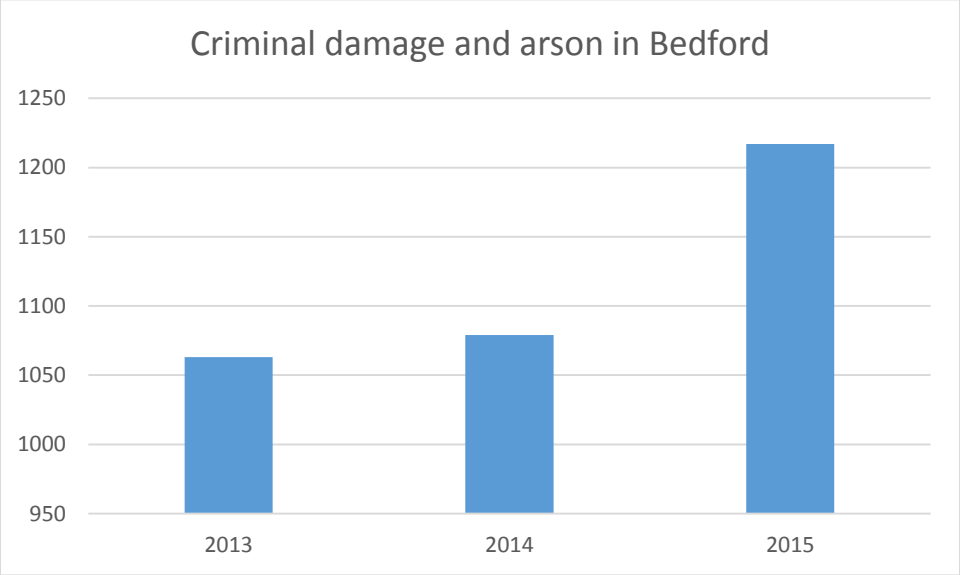
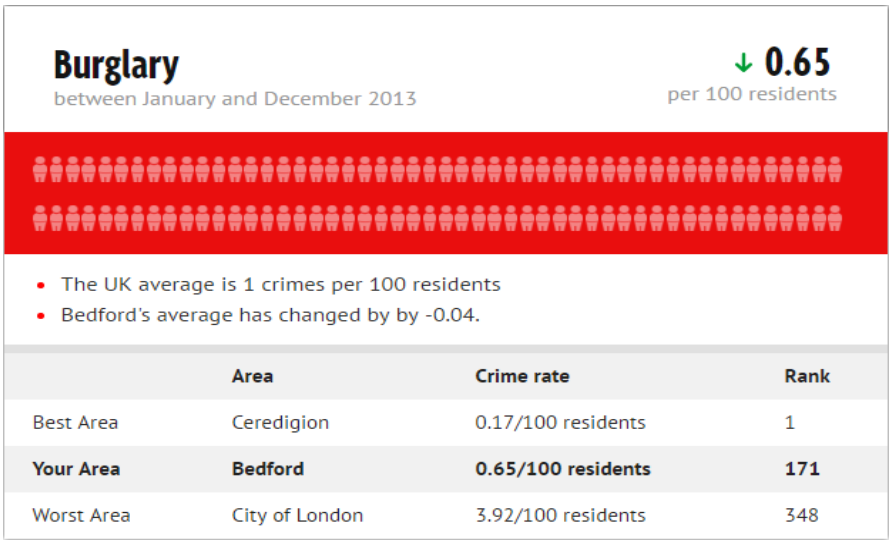


Figure 6: Criminal damage and arson in Bedford (Source: data.police.uk).

Burglary

Burglary is illegal entry to a premises for the purpose of committing any crime, such as theft. Police in Bedford face trouble dealing with this kind of crime. Bedford is a highly populated area and it is not an easy task to monitor every section of the neighbourhood. The statistics for burglary crime in Bedford from January 2013 to December 2013 showed a decrease of 0.65 per

100 residents (MIRROR.CO.UK, 2014). The overall average for UK burglary crime is 1 per 100 residents, whereas Bedford's burglary crime average altered by -0.04 and was ranked as 171st nationally (Figure 7) (MIRROR.CO.UK, 2014).



	Area	Crime rate	Rank
Best Area	Ceredigion	0.17/100 residents	1
Your Area	**Bedford**	**0.65/100 residents**	**171**
Worst Area	City of London	3.92/100 residents	348

Figure 7: Burglary in Bedford (MIRROR.CO.UK, 2014).

Drugs

The illegal possession and manufacture of drugs such as cocaine, heroin and other harmful substances have a detrimental impact on society. Police in Bedford consider it a major problem and deal severely with those selling and supplying drugs. The statistics for Bedford drugs crime from January 2013 to December 2013 showed that there was a decrease of 0.24 per 100 residents (MIRROR.CO.UK, 2014). Overall, drugs crime in the UK (2014) showed an average of 0.31 per 100 citizens and the Bedford drugs crime average changed by -0.02; it was ranked as 149th nationally (Figure 8).

Drugs
between January and December 2013

↓ 0.24
per 100 residents

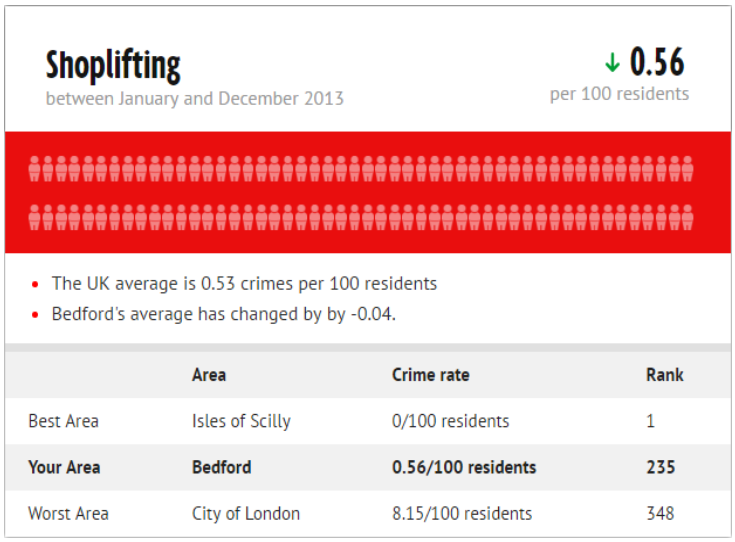
- The UK average is 0.31 crimes per 100 residents
- Bedford's average has changed by by -0.02.

	Area	Crime rate	Rank
Best Area	Isles of Scilly	0.04/100 residents	1
Your Area	**Bedford**	**0.24/100 residents**	**149**
Worst Area	City of London	5.16/100 residents	348

Figure 8: Drugs in Bedford (MIRROR.CO.UK, 2014).

Shoplifting

Shoplifting is the theft of goods from a shop, store or any trading place. Business owners are very concerned about shoplifters in the area and Bedford police have strict policies to deal with shoplifters and control crime in the area. The survey from January to December 2013 shows that in Bedford shoplifting crime reduced by 0.04 per 100 citizens, falling to 0.56 per 100 citizens (MIRROR.CO.UK, 2014). The overall UK shoplifting crime average is 0.53 per 100 residents (Figure 9).



Shoplifting
between January and December 2013

↓ 0.56
per 100 residents

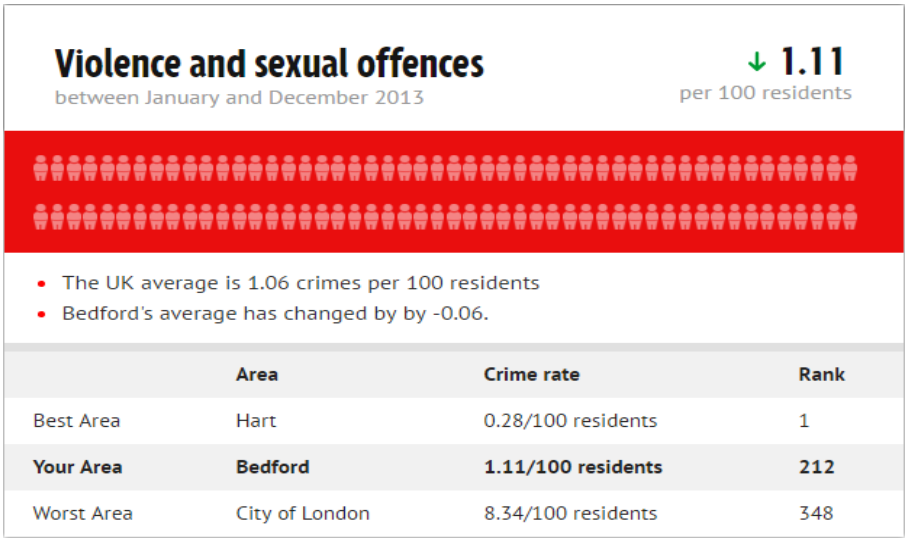
- The UK average is 0.53 crimes per 100 residents
- Bedford's average has changed by by -0.04.

	Area	Crime rate	Rank
Best Area	Isles of Scilly	0/100 residents	1
Your Area	**Bedford**	**0.56/100 residents**	**235**
Worst Area	City of London	8.15/100 residents	348

Figure 9: Shoplifting in Bedford (MIRROR.CO.UK, 2014).

Violence and Sexual Offences

Sexual violence is the act of carrying out sexual activity with a person without their consent. It is mostly women and children who are affected by this type of violence and abuse (Becker, et al., 2010). It is the duty of the police to ensure the safety of residents. According to Mirror.co.uk (2014), the statistics for Bedford for violence and sexual offences from January 2013 to December 2013 showed that the average reduced by -0.06 per 100 residents (Figure 10). Bedford was ranked 212th of 348 in terms of violence and sexual offences.



	Area	Crime rate	Rank
Best Area	Hart	0.28/100 residents	1
Your Area	**Bedford**	**1.11/100 residents**	**212**
Worst Area	City of London	8.34/100 residents	348

Figure 10: Violence in Bedford (MIRROR.CO.UK, 2014).

Geographic Information Systems (GIS)

GIS technology is the collection and analysis of information that is utilized in the examination of crime by taking into consideration the target, crimes and criminals. The major aim of crime detection is to identify and create the information that is required to plan the allocation of police resources to prevent and decrease criminal activity (Chainey & Ratcliffe, 2013). GIS analysts and crime experts play a significant role in providing essential and significant data for decision-makers. It has been established that the investigation of crime can also be utilized to

examine and improve police forces' strategies for dealing with the offence as well as to assist the police to identify criminal activity.

Discovering Crime Hotspots

Crime hotspots refer to areas of high crime density. GIS helps in questioning, analysing and overlaying databases to figure out the areas and patterns in relation to the geographical location where incidence of crimes has been high (Ratcliffe, et al., 2011). The hotspot analysis tool helps in identifying the spatial clusters of the areas that are statistically significant (high or low) in relation to crime density patterns. This is usually done with the help of a set of "weighted-data points" – for example, rate of criminal incidents per census block. The hotspot analysis also helps in identification of areas where the crime rate lies below normal. These are known as crime coldspots, which indicate the policies or environmental factors that are responsible for reduced crime rates. Such policies can then be adopted and integrated into the hotspot areas (Ratcliffe, et al., 2011).

The identification of hotspot areas helps in dispatching the appropriate law enforcement officers to handle the crime scene at hand. Furthermore, effective strategies could be adopted by tracking crime density patterns in order to intervene at the right time to counter rising criminal patterns. This also serves to warn the general public of the need for protective strategies (Bayer, 2010).

GIS and Crime Analysis

The ever-growing information society has presented the world with an opportunity to establish relationships between phenomena in a more advanced manner (Ferreira, et al., 2012). Technologically advanced products have provided humanity with several tools and techniques to

analyse, visualize and interpret relationships through the use of platforms (i.e. software and hardware). One of the most prominent platforms is that of geographic information systems.

The physical elements of the world (i.e. the atmosphere, mountains, rivers etc.) have been translated into forms to be displayed, manipulated and analysed through the use of GIS. This also includes characteristics such as police information on arrests, crimes and other incidents (Ferreira, et al., 2012). Considering this, two of the most common data models in GIS include raster and vector data models. Raster data, in particular, focuses on an image, which can be either a satellite photo or a remote sensing picture. The image, in simpler terms, is a grid formed by pixels that can either be increased (lower resolution) or decreased (higher resolution). Considering this, it has been indicated that each pixel in the image has an attributed value (Ferreira, et al., 2012).

In contrast, vector data is a representation of basic units of information, i.e. polygons, points and polylines (Figure 11). The point feature on an image acts as a discrete location; the polygon feature represents the geographic area in the map; and the polyline feature on the map is represented by a line on the map.

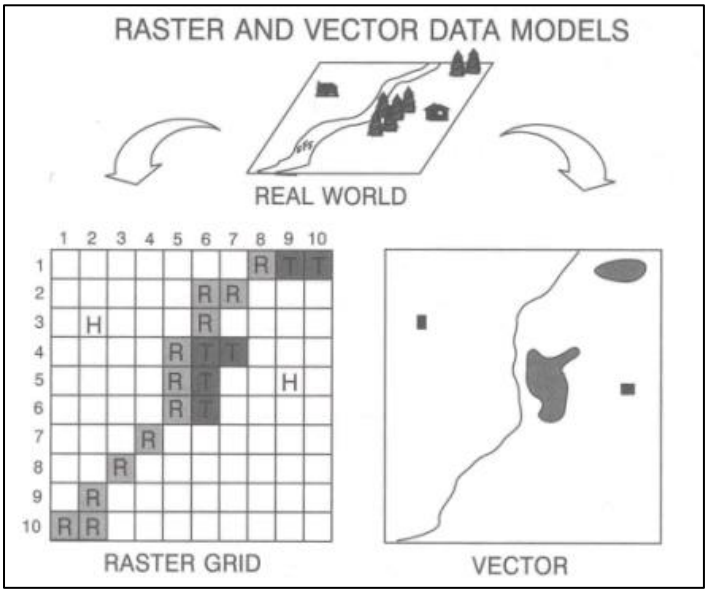


Figure 11: Raster and vector (Anon., 2007).

Performing Radial Analysis

Geographic information systems (GIS) have frequently been used to measure the types and degree of the problems within a limited location (Anselin & Getis, 2010). Analysts can study and visualize certain locations to determine the patterns and trends of criminal activity and events, with the option of quickly eliminating excess information (Ferreira, et al., 2012). The system can focus either on a single location or on multiple locations (Figure 12).

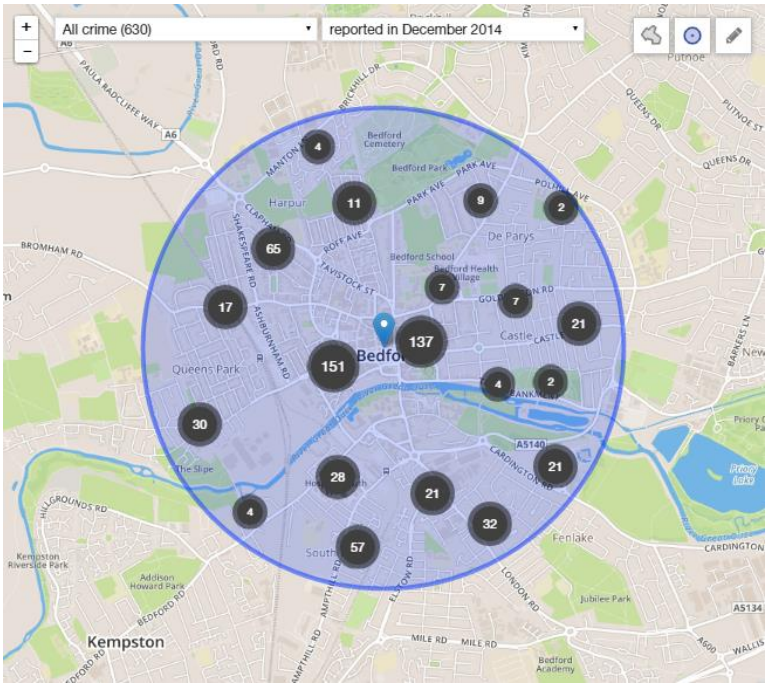


Figure 12: Bedford crime analysis (Source: Police UK, 2016).

Identification of Clusters of Events

GIS has a dominant role in identifying the areas with dense clusters of incidents (hotspots). The areas with clusters of incidents often demand special attention from law enforcement agencies. The use of GIS in the identification of hotspots provides a reliable approach to assessing and measuring criminal events (Alanzy, 2007). For example, the use of GIS allows the calculation of violent crimes and other crimes on a daily, weekly and monthly basis.

Comparing Locations

GIS also allows comparison of multiple locations at the same time (Figure 13). The use of GIS helps in identifying the different offence types and the areas where they overlap (Ceccato & Snickars, 2000). Furthermore, it helps in determining areas with chronic issues, while indicating the trends and patterns of the movement of crime from one location to another.

Summary of the Chapter

GIS are extensively used to optimize the schedules of law enforcement agencies. Not only has the identification of hotspots paved the way for enhanced methods of overcoming crime, but it also helps reduce overall costs. It has identified the increasing socio-economic benefits that GIS provides in terms of cost reduction, improved communication, and enhanced record keeping and decision-making. While it is tempting to think that GIS are a contemporary technology, evidence has been provided of their conceptual roots in the 21st century.

From the previous studies covered in this chapter, it is possible to see that crime analysis has been developed, improved and merged with new technologies in the last three decades, and especially with GIS techniques and applications. Therefore, this will lead to conduct a new study with a slightly different approach and to focus on the relation between GIS and specific kinds of crime.

CHAPTER 3: DATA AND METHODOLOGY

Data

Data for the study was collected and arranged in three groups. The first group comprises information on the geographic characteristics of Bedford. More precisely, there are facts and figures on physical and human characteristics. The second group of data is based on police records, while the third data group contains census information for Bedford.

Spatial (Geographical) Data

Maps were required as a source of spatial information and were retrieved from the Edinburgh University Data Library (EDINA). These are Crown copyright maps, which are legitimate and capable of being transformed into several formats for digital analysis of data. Maps were acquired as the digital copies of the UK boundary datasets. EDINA provides different formats of maps matching several types of software such as ArcMap, MapInfo MIF/MID, ArcInfo and others. These copies of maps are available for use by teachers and researchers. EDINA helped the researcher to gain access to the Reference Database for Education and Research Study and the United Kingdom Boundary Outline (UKBORDERS). The process was completed with the support of the Economic and Social Research Council (ESRC) and the Joint Information Systems Committee (JISC) (Schürer & Woollard, 2012). To build the base map of Bedford, Bedford's ward boundaries were selected as well as its lower layer super output areas (LSOA).

Census Data

The Office for National Statistics (ONS) is the recognized national statistical institute in the UK and functions as the largest independent producer of national statistics. It is the executive office of the UK Statistics Authority, formed in 2008 as a non-ministerial department, and is

responsible for providing reports directly to Parliament. The ONS designs and conducts the census data for England and Wales as well as extending its services to combine the data from England and Wales with data from Northern Ireland and Scotland to give a complete overview of the UK's population.

A Census was conducted in 2014 by the ONS in Bedford. The estimated population for Bedford Borough in mid-2014, according to the 2014 census, was 163,900; it rose from 148,100 in mid-2001 (Figure 13). This indicates that the population is rising by an average of 0.7% annually. According to the ONS project overviews, the population of Bedford Borough is expected to rise to 182,400 by 2023. This translates into an overall 8% increase in population for each year between 2014 and 2023 (Bedford.gov.uk).

Age	2001	2014	2001-14 Change	2001-14 % Change
0-15	30,700	33,100	2,400	7.8
16-29	27,100	27,900	700	2.7
30-44	33,400	33,000	-400	-1.2
45-64	34,800	42,100	7,200	20.8
65-74	11,700	14,800	3,200	27.2
75-84	7,700	9,200	1,500	19.3
85+	2,700	3,900	1,200	45.0
Total	**148,100**	**163,900**	**15,800**	**10.7**

Figure 13: Change in population in Bedford Borough with respect to age (Bedford.gov.uk).

For analysis from different demographic perspectives, it was necessary to analyse the results of crime throughout Bedford. For this purpose, sum of population data was required to transform it for analysis. Thematic maps have been used to show the distribution of the population in different areas of Bedford (Figure 14). Maps are aggregated using different colour palettes, where darker colours represent higher populations than brighter ones. This is one of the widely used methods that enable one to observe population distribution. This method has been used to

represent the density of population with respect to each area, since this makes ratios easier to understand.

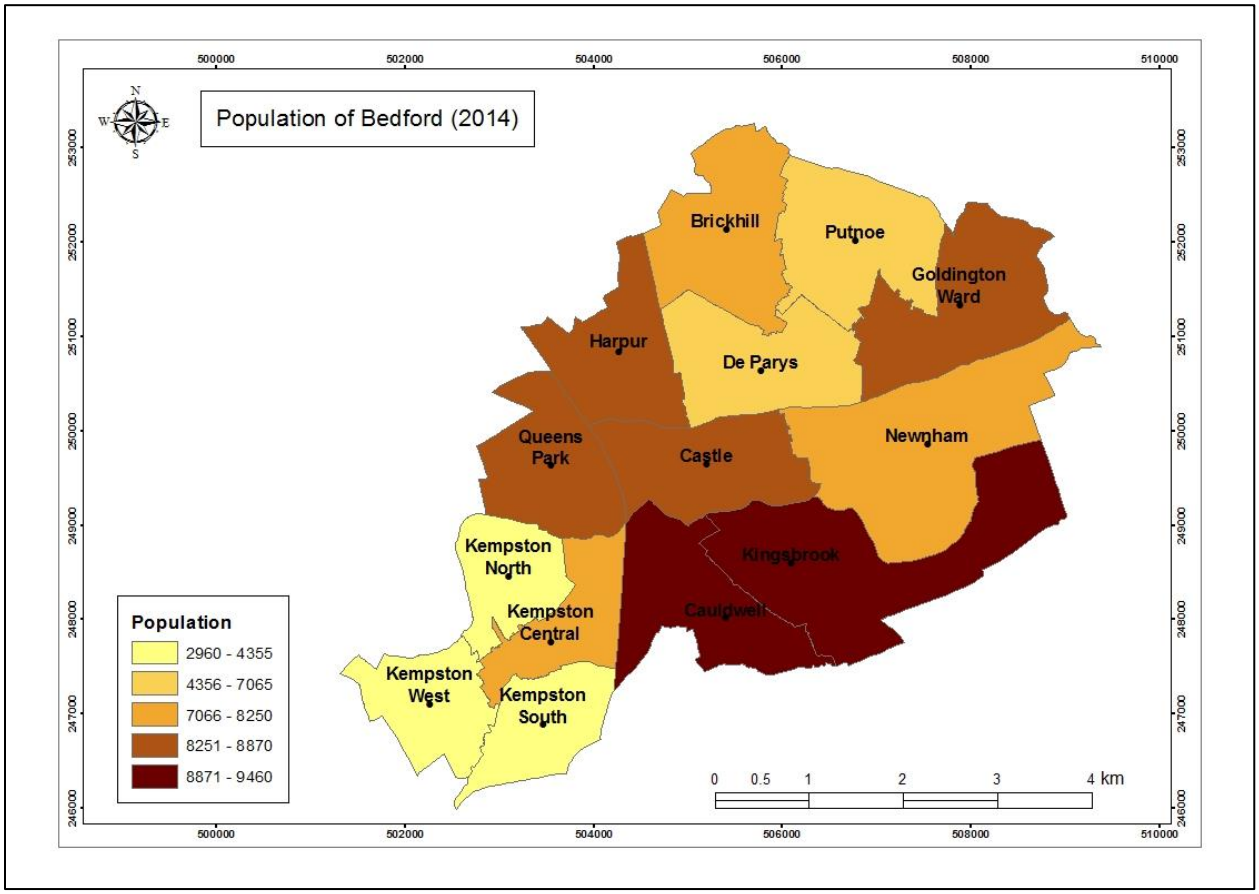


Figure 14: Distribution of population across different wards in Bedford.

These maps help in the creation of a spatial index to evaluate the incidence of crimes with the help of statistical tools. Data analysis of this type enables the researcher to conduct the study at a micro level, where the town is divided into subsections to gain statistically equivalent results.

Crime Data

Data pertaining to crime was acquired from https://data.police.uk. Police reports provided information on the incidence and frequency of crime. Street-level reported crimes were selected from this source. This means that the majority of crime hotspots occur on the streets of Bedford.

Information for crime in Bedford includes geo-referencing of the different crimes. To strengthen the foundations of the study, information on crimes was required; it was retrieved from the police reports and was utilized as the principal database for this study. These reports helped to evaluate the crime geographically, inclusive of the other determinants of types of crime prevalent in Bedford.

According to the datasets retrieved from the police service, the crimes are divided into 16 categories. The number of crime for each of the years 2013, 2014 and 2015 and the period 2013–2015 are presented in tables 9, 10, 11 and 12 respectively (see the appendix). The tables represent the occurrence of crime for 16 categories each month. Each column represents a crime category and the frequency of occurrence.

Table 2: Shows the variables obtained from crime datasets.

Variables	**Description**
Prominent Crimes	16 crimes have been reported in datasets from the police service as being the most common in Bedford.
Yearly Analysis	Analysis has been conducted to describe the incidence and variance of crime on a yearly basis.
Seasonal Analysis	The datasets describe seasonal variations (spring, summer, autumn and winter) to help detect the impact of seasons on the incidence of crime.
Months	The datasets provide insight into each crime in particular for all 12 months of the years 2013, 2014 and 2015.

Methodology

Preparation of Recorded Crime Datasets

A geodatabase format was used to cover the recorded crime datasets for the years 2013 to 2015. ArcMap is an embedded component available in the ArcGIS package. ArcMap (Version 10.3.1) was applied for spatial representation of the geo-references for datasets for all crime

locales. However, it took three phases to derive the geographic data. In the first phase, the original data was divided into datasets in order to categorize the crimes for each year (2013–2015). In the second phase, analysis of datasets was performed through "selection by attribute tool". This is one of the options available in the ArcMap. In the third phase, three types of crime were selected using the same tool. The crimes selected are as follows: criminal damage and arson, violence and sexual offences, and antisocial behaviour. These crimes were selected because they were the most reported crimes in Bedford. Furthermore, segregation of crimes was expected to help to precisely implement GIS techniques and therefore provide a more detailed view of the efficiency of GIS.

The spatial joining functions in the ArcMap are used for computation of the selected wards. The spatial joining function is applied when there is a need to compute particular hotspots to be identified. In this study, these points are the criminal events within the wards (polygon). The information retrieved from spatial joining is further used in evaluation of the correlation coefficients and regression models. In this study, the data was retrieved for all the reported crimes in Bedford Borough, which were limited by applying the spatial joining tools. This was necessary to limit the crime data to focus on Bedford, which is the area of concern in the study. The same function was applied again to isolate crime data for each ward in Bedford.

Identification of the Spatial and Temporal Concentrations of Crime

One particular analytical technique that has been persistently used by crime analysts for GIS is kernel density estimation. This is also referred to as the kernel density technique, which is applied to map the density values for given events or data points. The major concern to be considered when applying the kernel density technique is the selection of a suitable bandwidth or radius if a circular window is used, because this influences the quality of smoothing and therefore the authenticity of the filtered information. The kernel density technique has been selected because

it is a valuable tool in ArcMap to identify the hotspots in the area and because this is the method considered most relevant for epidemiologic targeting of the points of analysis within the hotspots. Mostly, the bandwidth for GIS applications is selected by considering the geographic extent to which the points make a pattern. This is one critical factor that can produce misleading density values and maps that are either too spiky or smooth in appearance.

The most important feature that requires core concentration is the determination of the distribution of the event points within the crime hotspot area (Chainey & Ratcliffe, 2013). The three spatial approaches that can be applied for this purpose are dispersed, cluster and hotpoint. An example of dispersed approach is the location of a vehicle stolen from inside a retail car park. Conversely, cluster approach means the possibility of crime incidents in the area surrounding the location; for instance, a club or a bar that might act as a source of crime. A hotpoint, on the other hand, is a crime hotspot where a single location is repeatedly subject to a crime, such as repeated burglaries in a school. For this study, the cluster approach is selected.

Detection of clusters is achieved through the calculation of frequency in a specified circle and evaluation of result counts to deduce the statistical significance of the circular distribution. This technique is particularly used in identification of crime clusters as well as for analysis of the events taking place within the specific spatial hotspot in order to identify the periods when particular criminal activities are peaking.

As far as the temporal distribution of crimes is concerned, the time of the criminal incident is of critical importance. Temporal analysis is easier for certain crimes such as violent ones because the victims are more aware; for crimes with no witnesses, the time of the incident is estimated based on the available evidence – there is no precise timing available, only a range of possible times. Ratcliffe (2004) specified a number of general approaches for performing temporal

clustering when this is the case. Due to the lack of detailed information on time units for day and night, the study utilized seasonal units. Each year was divided into four seasons. This step was performed in ArcMap in two steps. In the first step, a geodatabase of the work was created, and in the second step the data was loaded. Geodatabase files are significant as they allow a number of users to work on the same data. Users do not run into data lock issues, which are common in personal databases, and this makes their work easier (Hill & Paynich, 2013). Therefore, analysis for the three selected types of crime (criminal damage and arson, violence and sexual offences, and antisocial behaviour) was performed on yearly and seasonal units.

Chi-Square Test

The potential relationship between these study variables was identified through the chi-square tests by using SPSS version 23. The perfect correlation exists when the values obtained are less than 0.05. The chi-square test was utilized to evaluate compatibility or conformity between the anticipated and actual distributions of the crimes. This test has been mathematically formulated with the purpose of recognizing the main differences between two distributions. The chi-square test has been selected to identify any significant differences among crime types and other variables such as ward, age, gender and season. Furthermore, it will identify which of these variables have the strongest connections with crime types.

Multiple Regression Models

The best multiple regression models were identified in order to establish a link between each crime and its determinants. The option of "enter selection" was used for multiple regression modelling. This method was used as it allows the researcher to put aside collinearity by selecting only variables with higher correlation values and only the dependent variables that share low correlation with each other. Presumably, the independent variables have high correlation, which

will have a negative impact on the regression models and will need to be addressed. Principally, it is assumed in regression models that all independent variables in the study are linearly independent; this assumption is applied for calculation of each contributing variable (Ayalew & Yamagishi, 2005). Correlation analysis was performed for crime incidents during the period 2013–2015 and the results were applied to the model applications of the three selected types of crime. SPSS software (V.23) was used for correlation analysis and statistical modelling.

CHAPTER 4: DISCUSSION AND RESULTS

The spatial and temporal clusters for the three kinds of crime (antisocial behaviour, criminal damage and arson, and violence and sexual offences) will be presented in this chapter. In addition, the significance role of the demographic factors will be highlighted for the respective crimes. The chapter starts with the spatial distribution of types of crime, followed by a second key section containing a seasonal analysis of crimes. The patterns of spatial and temporal distribution achieved from the application of GIS techniques will be discussed in detail in this chapter; also, some of the demographic factors will be considered and will be discussed clearly during the statistical analyses. Subsequently, the statistical findings will be presented as statistical diagrams and tables demonstrating the variations in the crimes.

Spatial Distribution of Types of Crime

Some previous studies in crime analysis have revealed that crime has a local or regional distribution. Spatial distribution is highly important to illustrate the clustering of crime because it shows the concentration of the hotspots running from which any direction. Crime tends to cluster geographically and this will lead to hotspot analysis, making it possible to recognize and visualize crime (Wang, 2005). More precisely, crime hotspots can be addressed by creating accurate crime maps, more efficiently allocating police resources and predicting crime. The spatial mapping methods usually categorize hotspots on the crime maps.

The application of GIS techniques provides a precise view of crime clusters/hotspots and their spatial distribution; below are the details of the approach to using GIS applications in the spatial distribution of crime.

Spatial Distribution of Antisocial Behaviour

The spatial distribution of antisocial behaviour in 2013 shows that the concentrations of antisocial behaviour were localized more in the centre (i.e. Castle, Harpur and Cauldwell wards) and the southern parts of the town than in the northern parts of the town, which confirms that crime levels in the southern parts (i.e. Kempston Central, North, West and South) were very high compared with the northern parts (Brickhhill and Putnoe), except for a minor cluster at the north-east location of the northern parts (Goldington) (Figure 15).

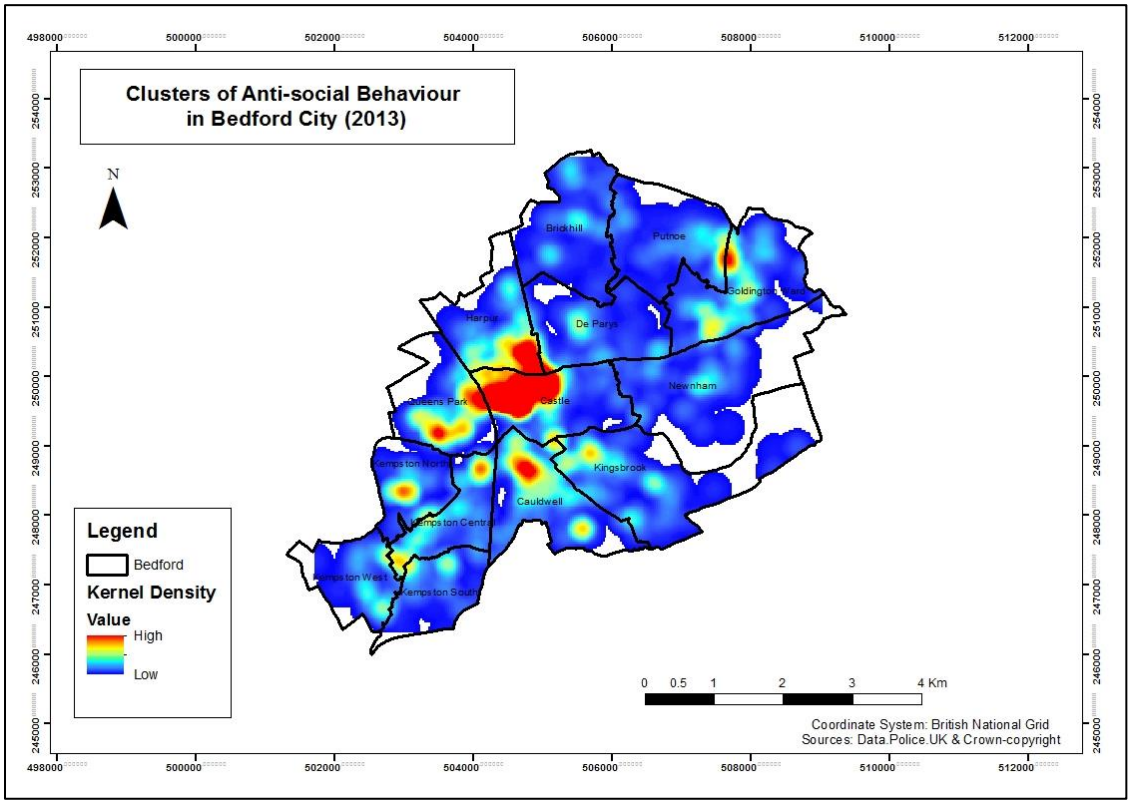


Figure 15: Clusters/Hotspots of antisocial behaviour (2013).

In 2014, the distribution of antisocial behaviour crime was concentrated in the far north-east and north-west of the town (i.e. Putnoe, Goldington and Newnham) and the far south-west (Kempston Central) as well; the spatial distribution of antisocial behaviour crime was different from and more decentralized than in 2013. Moreover, the concentration of the antisocial behaviour,

still in the middle of the town, but with slight change of this cluster's concentration to be more less than 2013 in Queens Park ward and increased in Harpur and Cauldwell wards (Figure 16).

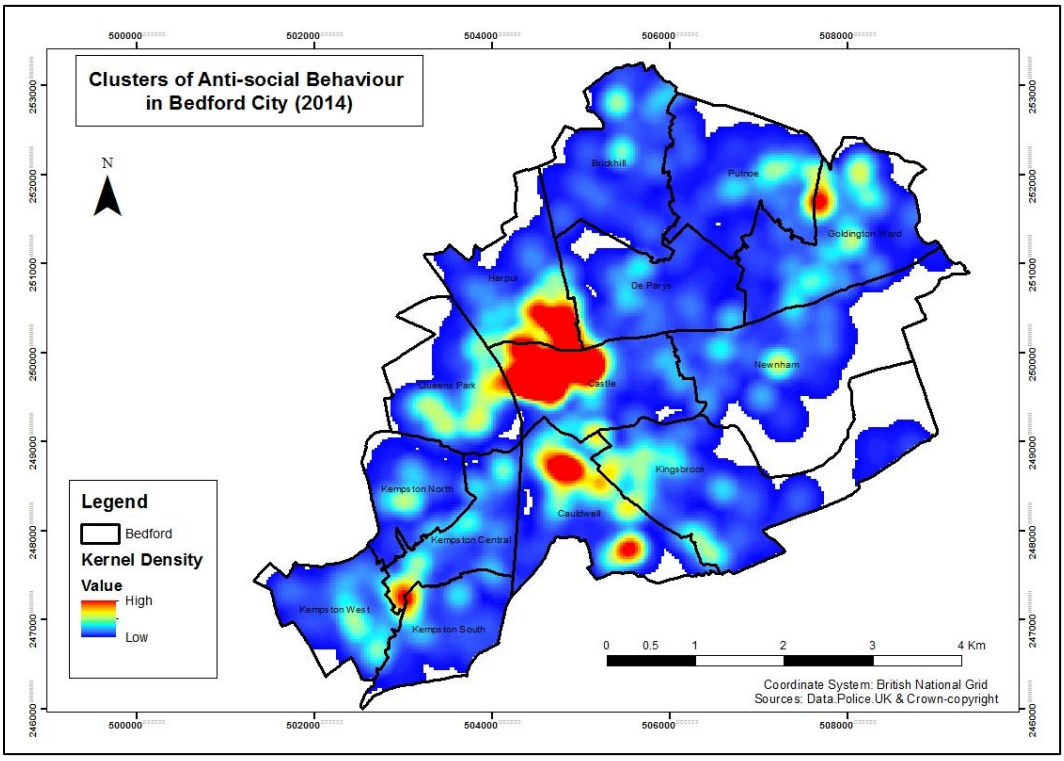


Figure 16: Clusters/Hotspots of antisocial behaviour (2014).

The spatial distribution of antisocial crime in 2015 became more centralized towards the centre of Bedford than in the northern and southern parts of the town (Figure 17). The major cluster of crime was located in Castle, Harpur and Cauldwell wards, with a reducing crime level in Harpur ward, and this is clear from the reduced cluster in the centre compared to the map of 2014.

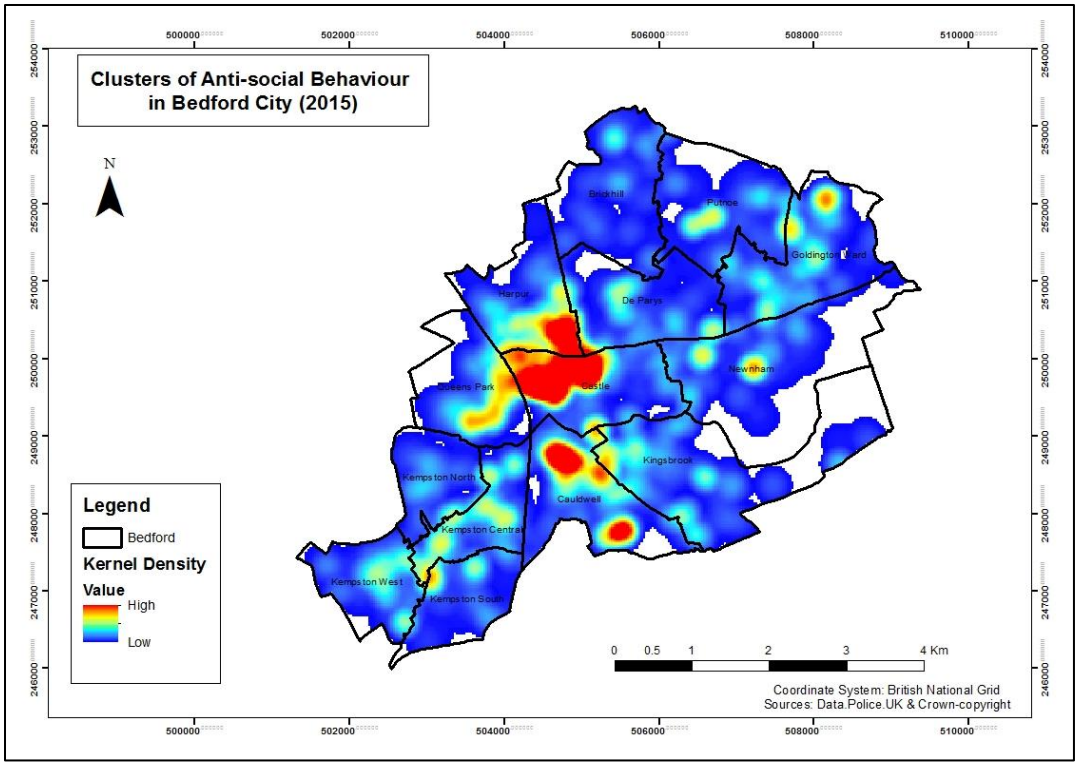


Figure 17: Clusters/Hotspots of antisocial behaviour (2015).

The results achieved after the application of GIS techniques clarify the data and make it possible to trace out clear patterns for crime investigation. The wards of Harpur, Cauldwell, Queens Park and Castle remained the wards with the highest clusters/hotspots for antisocial behaviour. The above figures show fluctuations in crime for 2013, 2014 and 2015 and these wards persistently show high levels of such crimes. The location of minor clusters has become more concentrated in specific clusters sequentially over the years, which means crime has become more highly clustered in the centre of Bedford. (i.e. De Parys, Harpur and Castle). From 2013 to 2015, the expansion is worthwhile where the major clusters are found distributed in more vicinity, near the aforementioned hotspots (Figure 18).

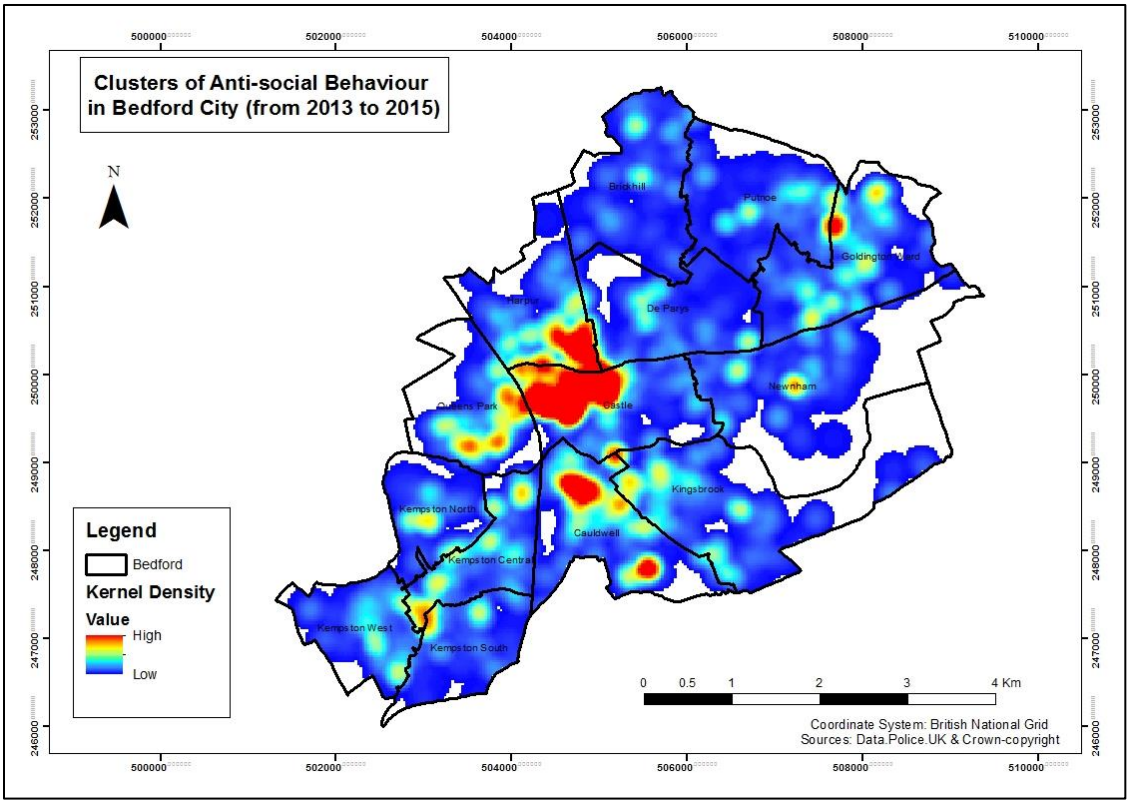


Figure 18: Clusters/Hotspots of antisocial behaviour from 2013 to 2015.

Spatial Distribution of Violence and Sexual Offences

Violence and sexual offences are distributed across many wards in Bedford (Figures 19, 20, and 21). The following points illustrate and discuss the highlighted spatial hotspots and clusters:

1- In Cauldwell ward, violence and sexual offences increased in 2014 more than in 2013 and became more clustered and centralized in 2015 into two hotspots.

2- In Queens Park ward, the clustering of violence and sexual offences increased from 2013 to 2015. This cluster was concentrated into two hotspots in 2014 to a greater extent than in 2013 and was also concentrated into one major hotspot in 2015.

3- In the southern part of Bedford (i.e. Kempston Central, West and North), violence and sexual offences increased from 2013 to 2015. The clusters of these crimes became centralized in three hotspots in 2015 to a greater extent than in previous years.

4- Violence and sexual offences extended towards Harpur ward from Castle ward on two axes. One of these axes extended and increased obviously towards the north, while the other extended slightly towards the north-west.

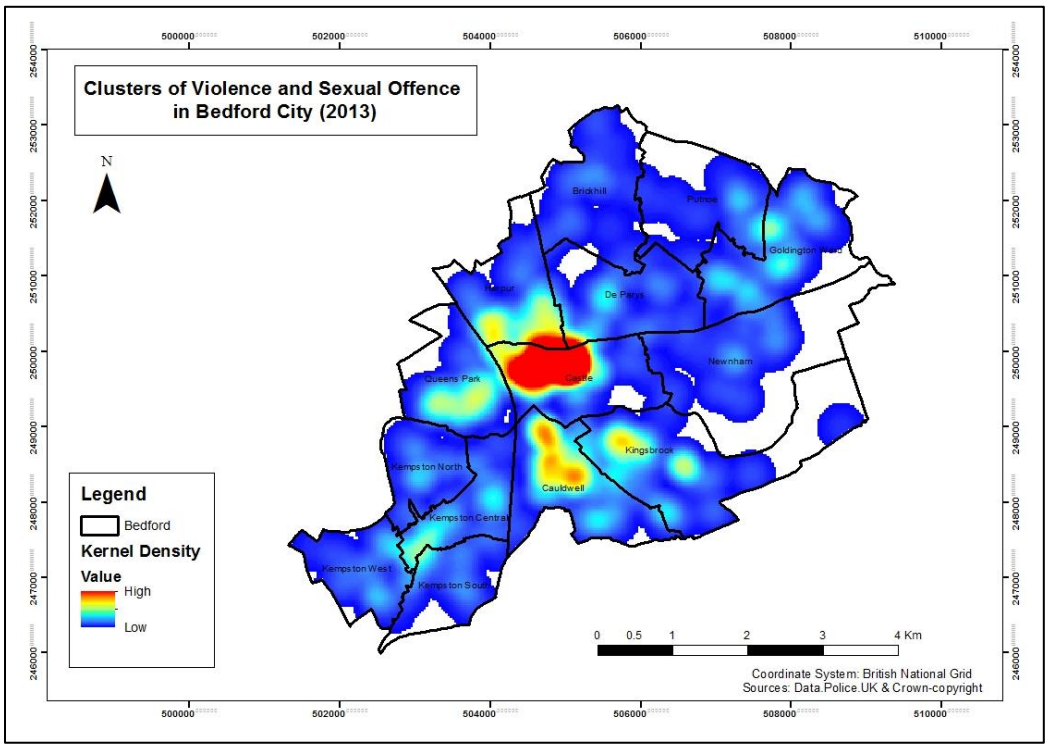


Figure 19: Clusters/hotspots for violence and sexual offences with GIS techniques (2013).

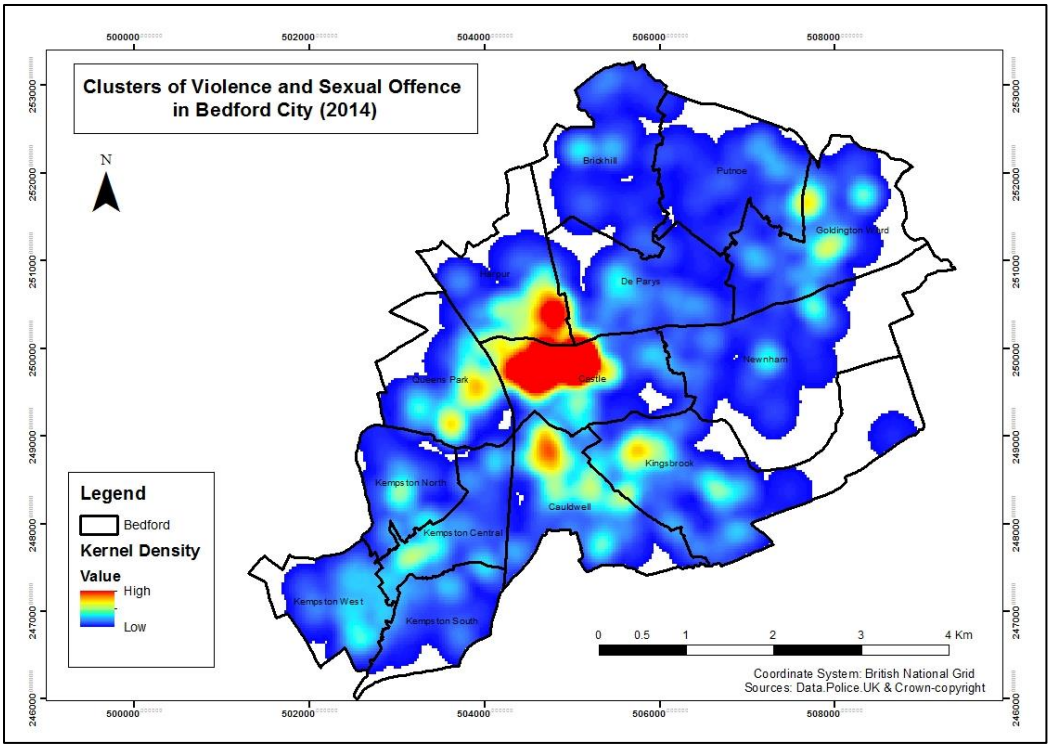


Figure 20: Clusters/hotspots for violence and sexual offences with GIS techniques (2014).

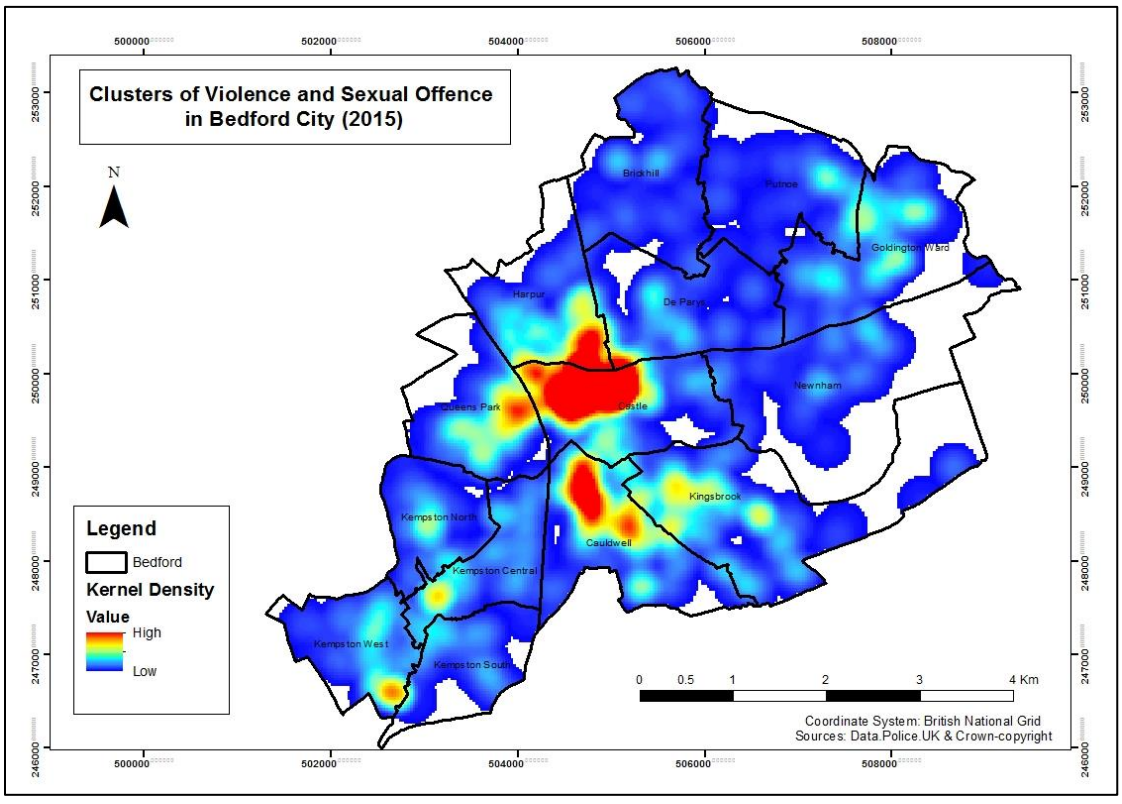


Figure 21: Clusters/hotspots for violence and sexual offences with GIS techniques (2015).

Incidence of violence and sexual offences showed a gradual increase from 2013 to 2015. In 2013, the number of reported crimes was 1,005, which increased to 2,207 in 2014. In 2015, crimes increased to 2,505, with some areas of higher concentration (Castle, Cauldwell, Harpur, Queens Park and Kingsbrook), while fluctuations persisted in the wards De Parys, Kempston North, West and Central, Goldington and Putnoe. As compared to 2013 and 2014, it is apparent that crimes of this type extended to a number of areas (Figure 22).

In general, from the above figures of the spatial distribution of violence and sexual crime it can be seen that the hotspots became centralized and extended towards the town centre, which means that crime either transferred or extended towards these wards from the centre, and also became more clustered in major hotspots in the southern part of the town.

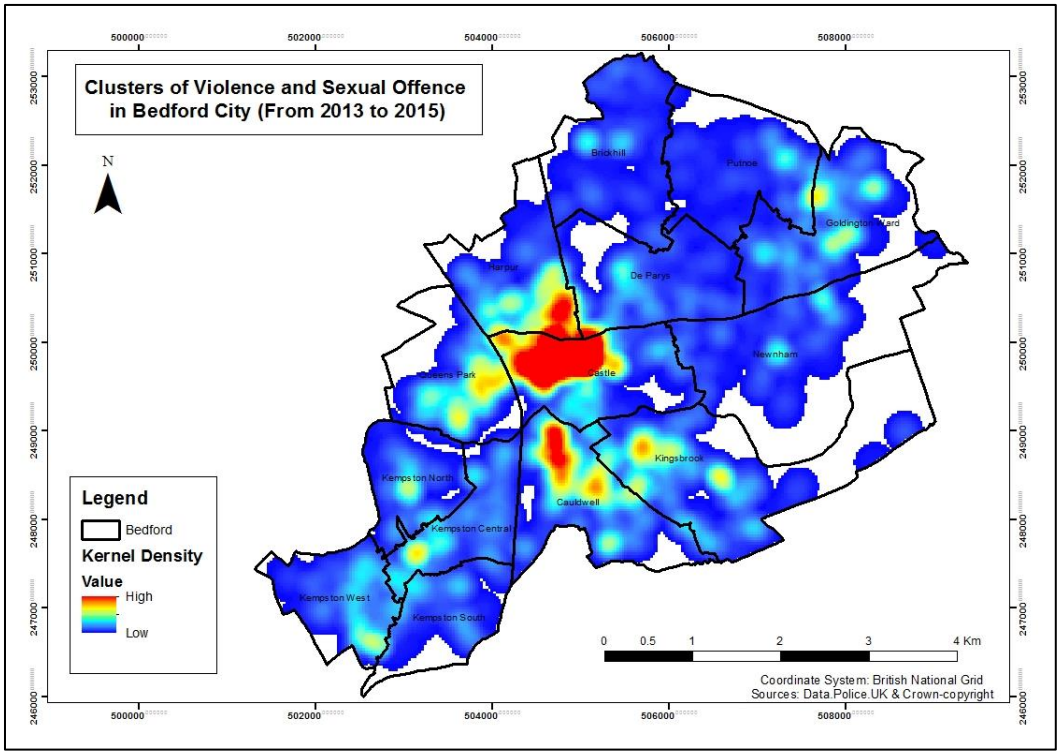


Figure 22: Clusters/Hotspots of violence and sexual offences (2013–2015).

Spatial Distribution of Criminal Damage and Arson

During examination of the outcome maps of the spatial distribution of criminal damage and arson during the period 2013 to 2015, it was noticed that the northern part of the town, specifically Goldington, had a scattered distribution of these crimes in 2013 (Figures 23, 24, and 25), while in 2014 these crimes started to become concentrated in a major hotspot in the north-east of Goldington. Moreover, the crimes became scattered again with the possibility of another major hotspot in future in the south-east of Goldington.

In Kingsbrook ward, there were two minor hotspots in 2013, while in Cauldwell there was one major hotspot with a minor hotspot close to it. In 2014, in these two wards crime began to reduce in Kingsbrook, and in contrast crime increased and became concentrated in one major hotspot in Cauldwell. In 2015, two major hotspots were established, one in Kingsbrook and another one in Cauldwell to the south of the previous major hotspot, which increased more than in 2013 and in 2014 and created a kind of a bridge between the two major hotspots.

The major crime hotspot occurred in the central part of the town and this major hotspot started to expand north and west in 2013, while in 2014, this expansion started to decrease with exciting a new minor hotspot in the Queens Park ward. In 2015, the major hotspot expanded north and west again. Furthermore, a new major hotspot developed on the border between Castle and Newnham wards.

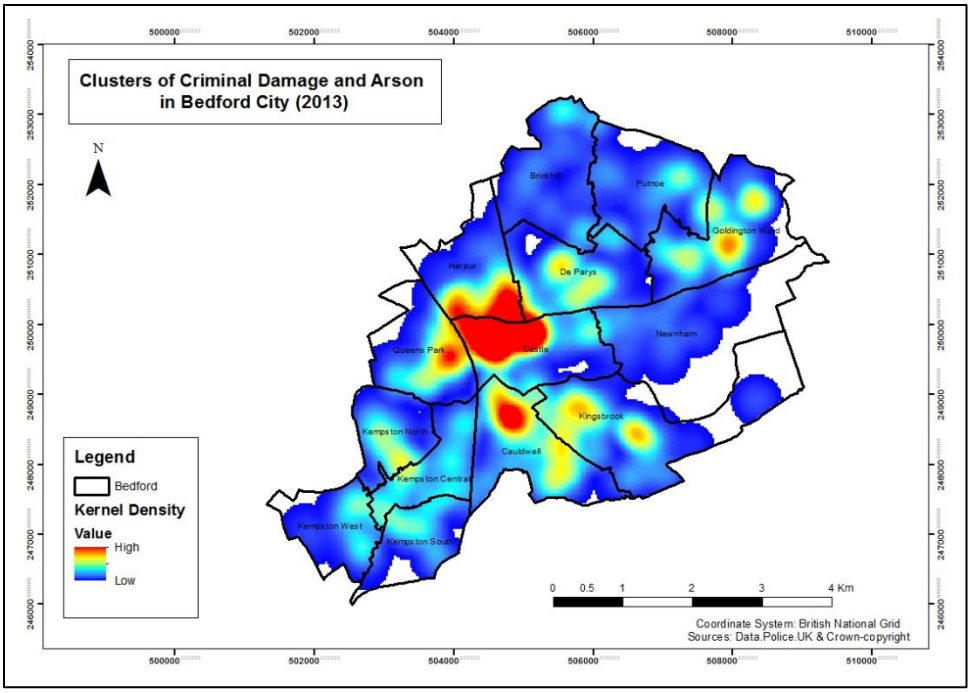


Figure 23: Clusters/Hotspots of criminal damage and arson in 2013.

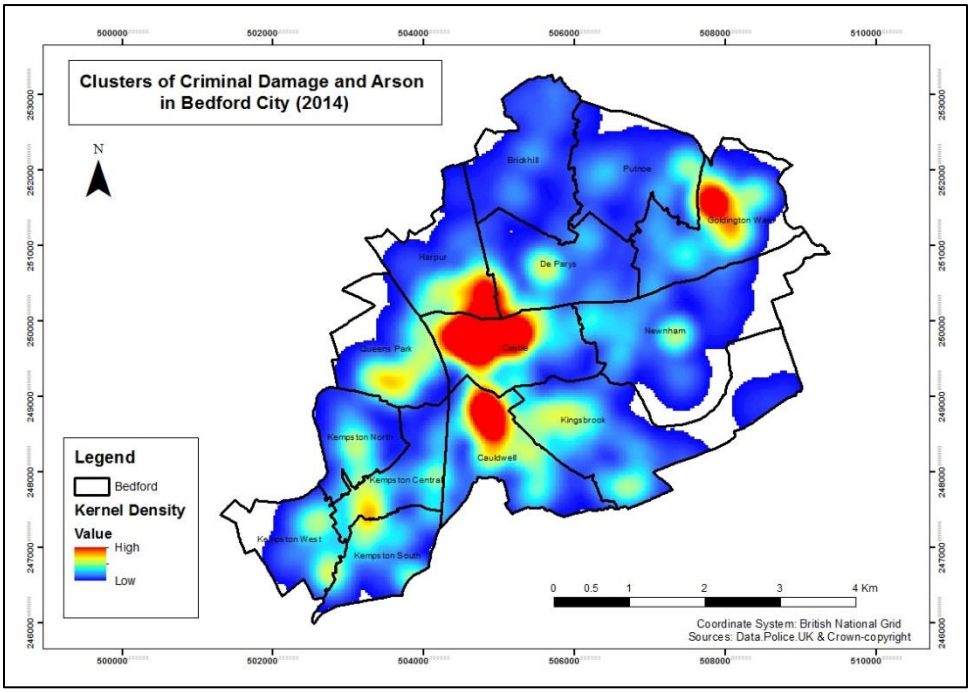


Figure 24: Clusters/Hotspots of criminal damage and arson in 2014.

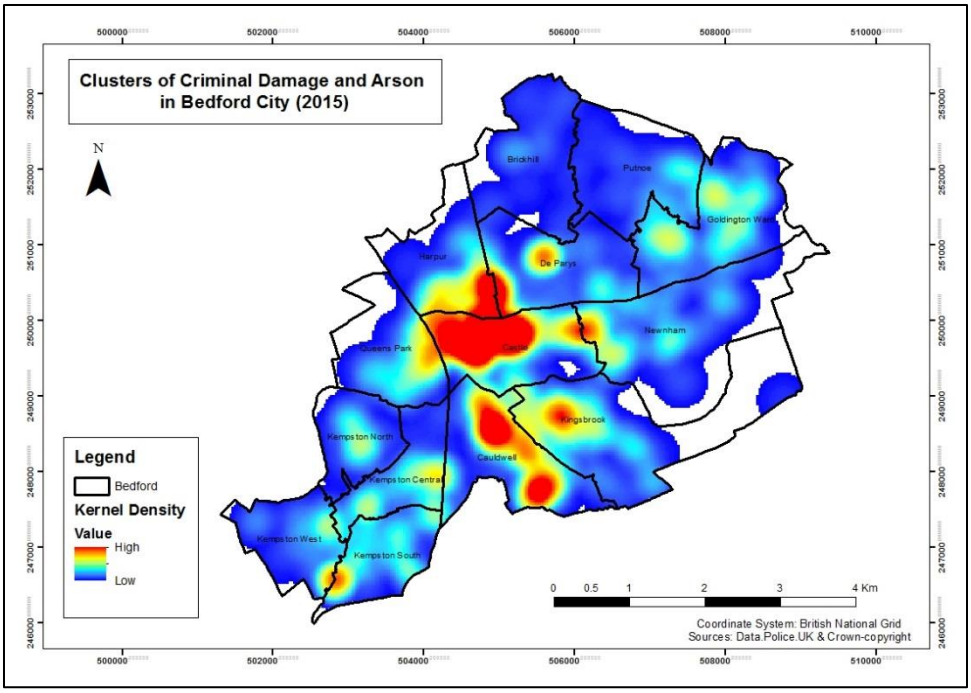


Figure 25: Clusters/Hotspots of criminal damage and arson in 2015.

The Results of Spatial Distribution of Types of Crime

The hotspots on the maps were used to represent the distribution of crime. Crimes were not evenly distributed, but appeared to be more prominent in some wards of Bedford than others. Through visualizing the clusters, it can be seen which of the wards reported the highest measure of crimes. According to Anselin et al. (2010), exploration of the causes of crime becomes easier with spatial distribution. Investigating and pointing out the specific crime activity at each spot leads to the creation of a holistic picture of crime incidence with respect to geographic and demographic factors (Schiller & Black, 2010). It is apparent from the spatial distribution of crime that some of the wards were more prone to crime than others; moreover, crime concentration was greatest in the centre of Bedford. The identification of hotspots and the cluster approach helps to reveal the correlations between geographical and other potential variables such as population characteristics. In addition, this knowledge is also used to direct everyday activities. People tend to limit their presence in certain places at particular times of the day or night to reduce their chances

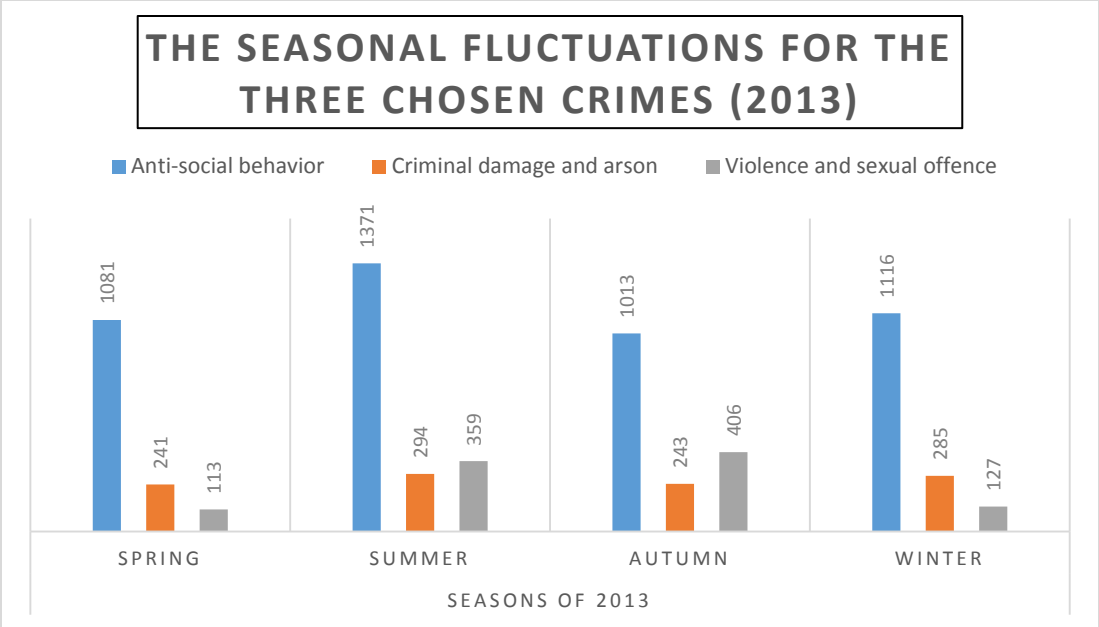
of becoming a victim of crime. This information is also used in community policing for assigning duties to police officials. The major motive is to identify areas with increased crime concentration and to investigate them to find out the causative factors so that the issues can be mitigated to control crime. This in turn generates responses to be implemented against these concentrations of crime.

Temporal Distribution of Crime

The clustering of crime shows not only spatial results, but also temporal ones (Ferreira, et al., 2012). The temporal distribution of crime will depend mainly on the seasonal data of reported crimes in Bedford. Hence, the temporal distribution has an obvious impact on crime analysis and crime mapping, which will lead to a good understanding of crime approaches. In this distribution, the time factor, which is represented by the seasons, will be the variable in the crime distribution.

Temporal Distribution of Antisocial Behaviour Crime (2013)

For 2013, antisocial behaviour remained highest during summer (1,371). Levels during spring, autumn and winter fluctuated only slightly. The specification of months for each season is given in Table 13 (see the appendix). According to Falk (1952), summers are vulnerable to higher crime rates because of an increase in outdoor gatherings and changes in social activity. In contrasting, a study conducted in Hong Kong specified the months of February, March, September and October as the more vulnerable periods for the occurrence of criminal activity (Chi, 2005).



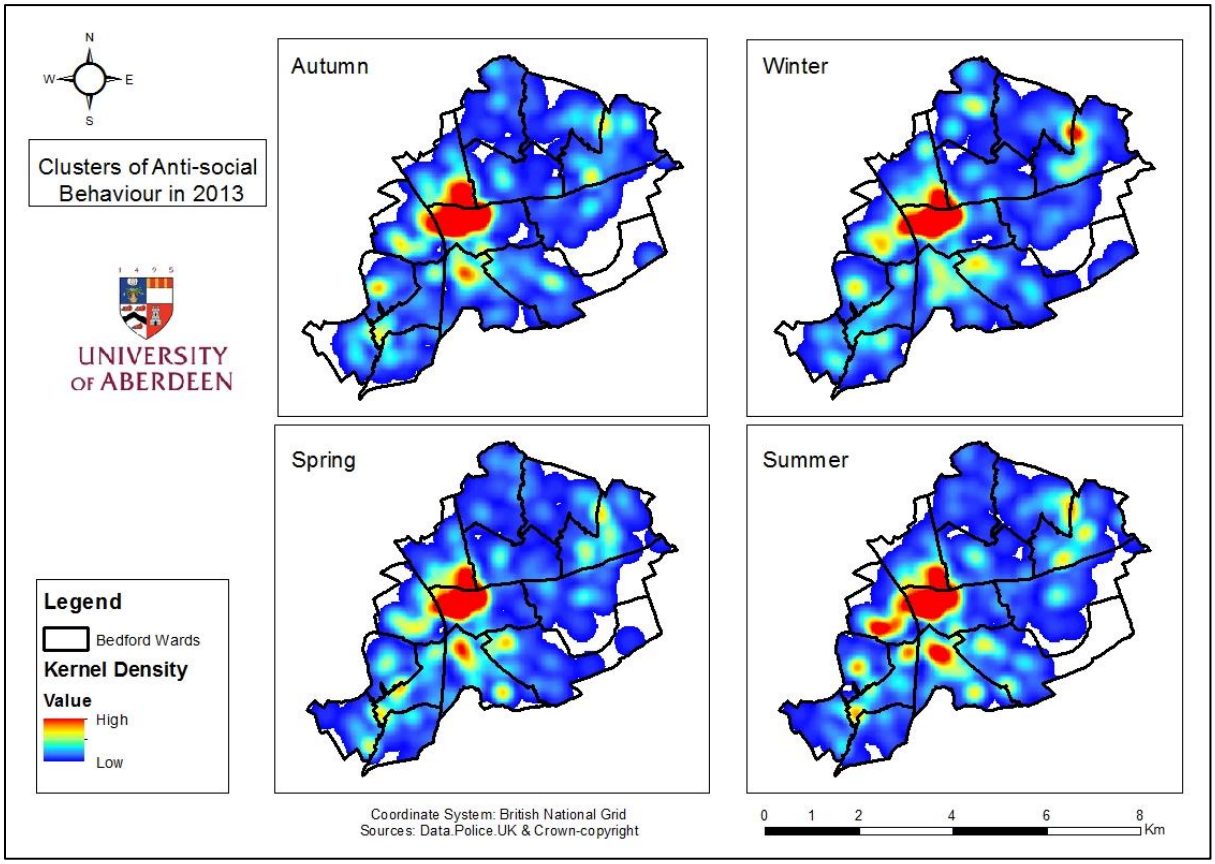


Figure 26: Clusters/Hotspots of antisocial behaviour (seasons of 2013).

For autumn and winter, the differences in cluster orientations appeared in the wards of Putnoe, Cauldwell and Goldington (Figure 26). The higher concentrations of crime existed in the wards of Harpur, Castle and Queens Park. Moreover, the differences in antisocial behaviour for winter and autumn were only slight.

The summer season revealed an extension of crime in Queens Park from Castle, Harpur and Cauldwell (Figure 26). These regions showed the highest concentrations, whereas Putnoe and Goldington wards seemed to show a reduced incidence of crime for the summer season. In spring 2013, the crime levels were low compared to the summer and winter.

Overall, for antisocial behaviour, the clusters tended to diminish in Queens Park, Putnoe and Goldington wards. Harpur, Castle and Cauldwell remained the areas of highest concentration. The lowest incidence of crime and antisocial behaviour was found to be in autumn (1,013) and spring (1,083).

Temporal Distribution of Criminal Damage and Arson (2013)

This remained the second most prevalent crime in Bedford in 2013, while its ranking dropped to third place in 2014 and 2015. The cluster hotspots according to season in 2013 for criminal damage and arson are shown in Figure 27. Apparently, crimes of this type were spread all over Bedford, but the areas in red show higher concentrations. Harpur, Castle, Queens Park, Cauldwell and Kingsbrook remained the wards of higher concentration throughout 2013, while fluctuations in crime concentration for different wards for each season can be viewed in Figure 27: the minor clusters mostly occurred in Putnoe, Goldington, De Parys and Kempston Central, East and North. The concentration of clusters is more extensive in the seasons of summer and, secondly, spring.

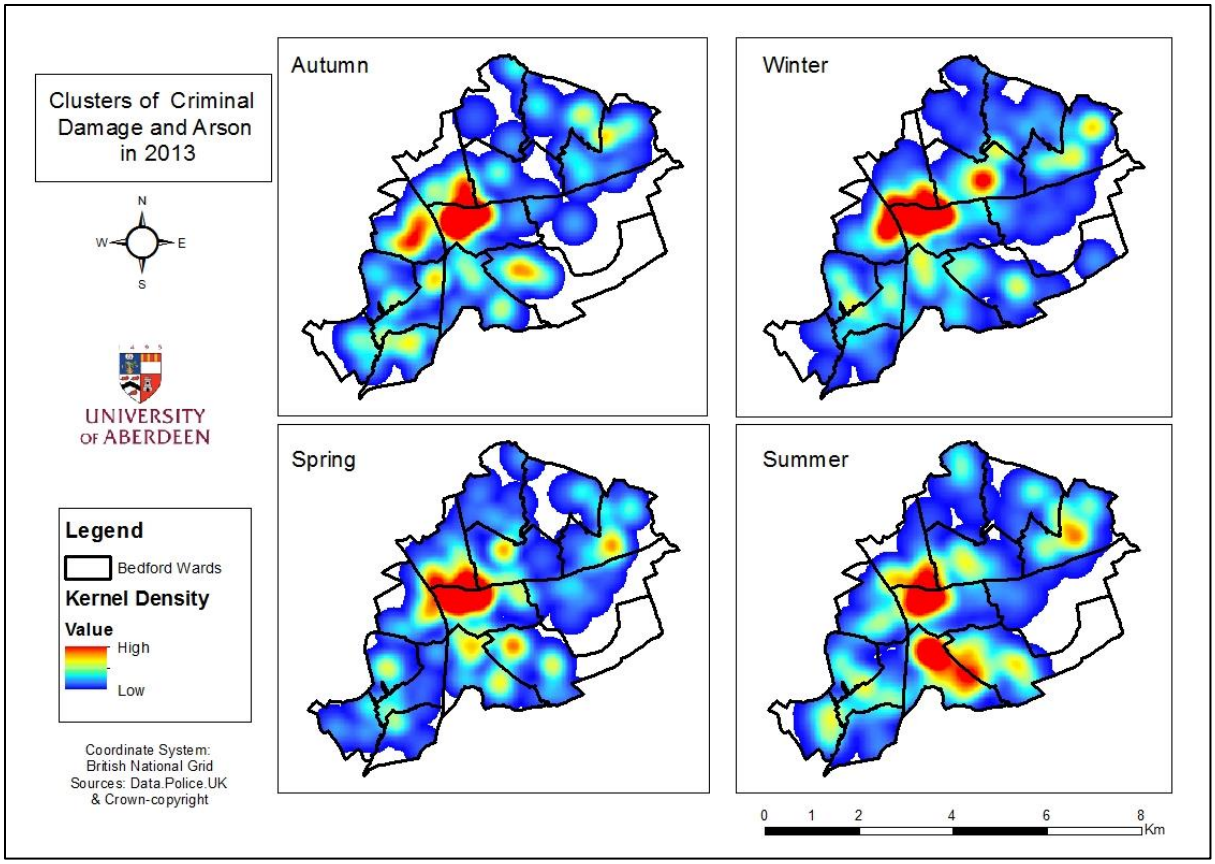


Figure 27: Clusters of criminal damage and arson (seasons of 2013).

The map for winter 2013 shows a decrease in crime concentration: in most of the areas, the concentration of crime turned low to moderate in areas including Kingsbrook, Cauldwell, Kempston West and Putnoe (Figure 27). The findings that incidence of crime is higher during summer than winter are also presented by Lauritsen et al. (2014). Crime mostly spikes in summer due to the increase in outdoor activities.

The map for summer shows a stark increase in crime concentration in Goldington, Kingsbrook, Castle and Cauldwell, while its expansion in other wards is also more prominent: areas including Kempston West, De Parys and Kempston North appeared to show higher than moderate crime concentrations (Figure 27).

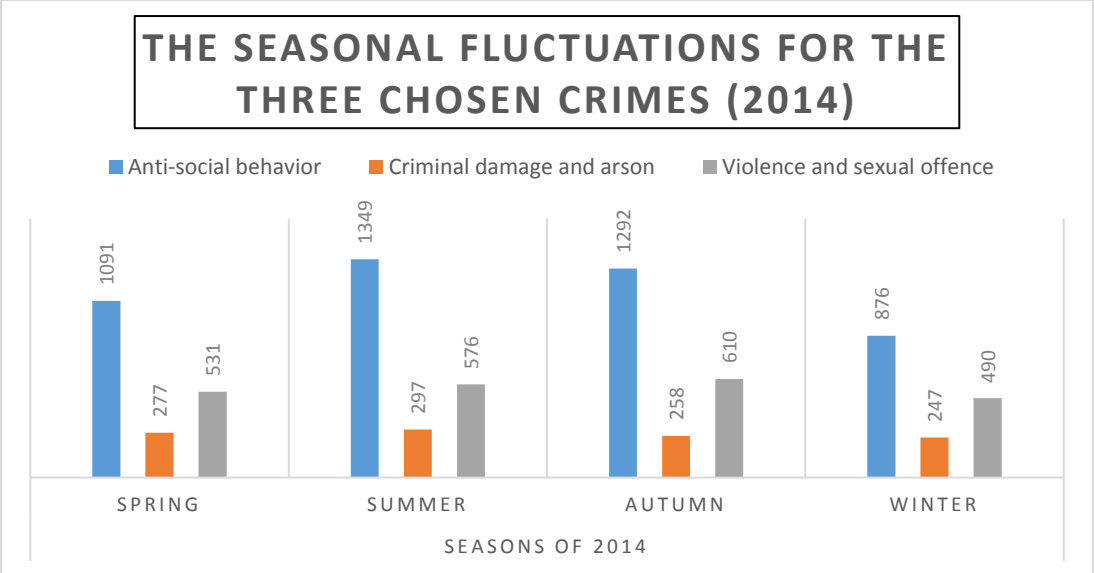
During autumn, the clusters were restricted to certain wards, with the highest concentrations being in Harpur, Castle and Queens Park. In addition, Kingsbrook, Putnoe,

Goldington, Kempston and Cauldwell presented higher than moderate concentrations for criminal damage and arson in Bedford (Figure 27).

It is apparent from the cluster orientations in the above figure that crime expanded during the spring season. Wards such as Goldington and Kingsbrook appeared to show higher crime concentrations than for autumn. Overall, the major hotspots in all seasons varied between one major hotspot and two or three major hotspots or/and minor hotspots.

Temporal Distribution of Crime (2014)

The diagram below provides a comprehensive overview of each of the three types of crime with respect to the seasons of 2014. Violence and sexual offences remained higher during autumn, while the antisocial behaviour remained higher during summer and autumn. The incidence of criminal damage and arson, although lower than the incidence of the other two crimes, was highest during summer and showed only a slight decrease in other seasons, with the lowest in winter.



Temporal Distribtuion of Antisocial Behaviour Crime (2014)

According to the dataset for 2014, the incidence of antisocial behaviour was also highest for the season of summer (1,349 reported crimes), but there was a significant decrease during

winter (876). For spring and autumn, it was 1,091 and 1,292 respectively (Table 14 in the appendix).

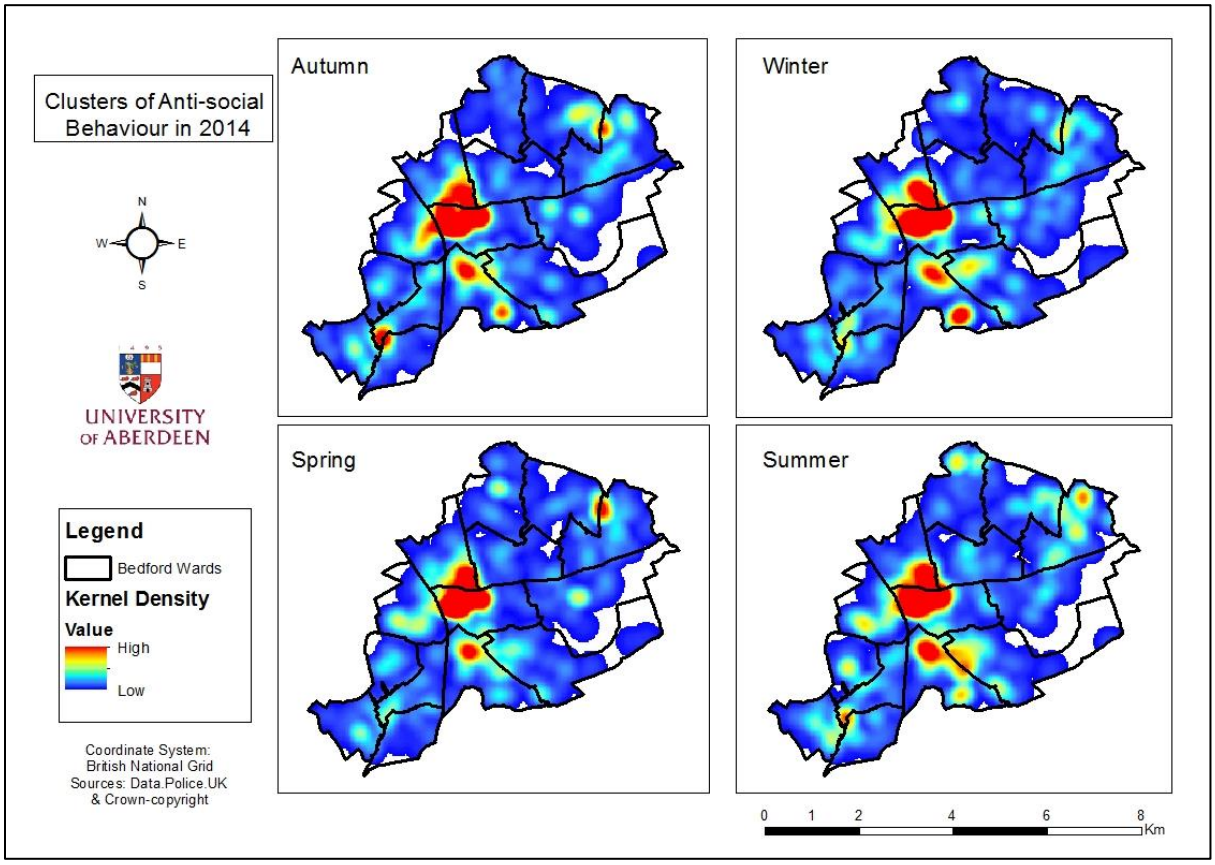


Figure 28: Clusters/Hotspots of antisocial behaviour (seasons of 2014).

In 2014, antisocial behaviour decreased slightly during summer compared to summer 2013 and increased during the winter of 2014 to develop two more major hotspots (Figure 28), while in autumn two major hotspots in the north and south of the town were established. During spring, no changes were seen in these kinds of crimes compared to 2013.

Temporal Distribution of Violence and Sexual Offences (2014)

For 2014, the wards with the highest clusters of violence and sexual offences included Castle, Harpur, Cauldwell and Kingsbrook, while Goldington, Queens Park and Kempston Central appeared to show moderate concentrations (Figure 29). However, examination of the maps from 2014 reveals a drastic change in the distribution patterns of crimes.

In autumn 2014, the three areas that reported the highest violence and sexual offences in Bedford were Castle, Harpur and De Parys. The wards that appeared to show moderate concentration were Queens Park, Kingsbrook, Putnoe, Cauldwell and Kempston North, West and Central. Brickhill and Newnham showed the lowest concentrations for violence and sexual offences (Figure 29).

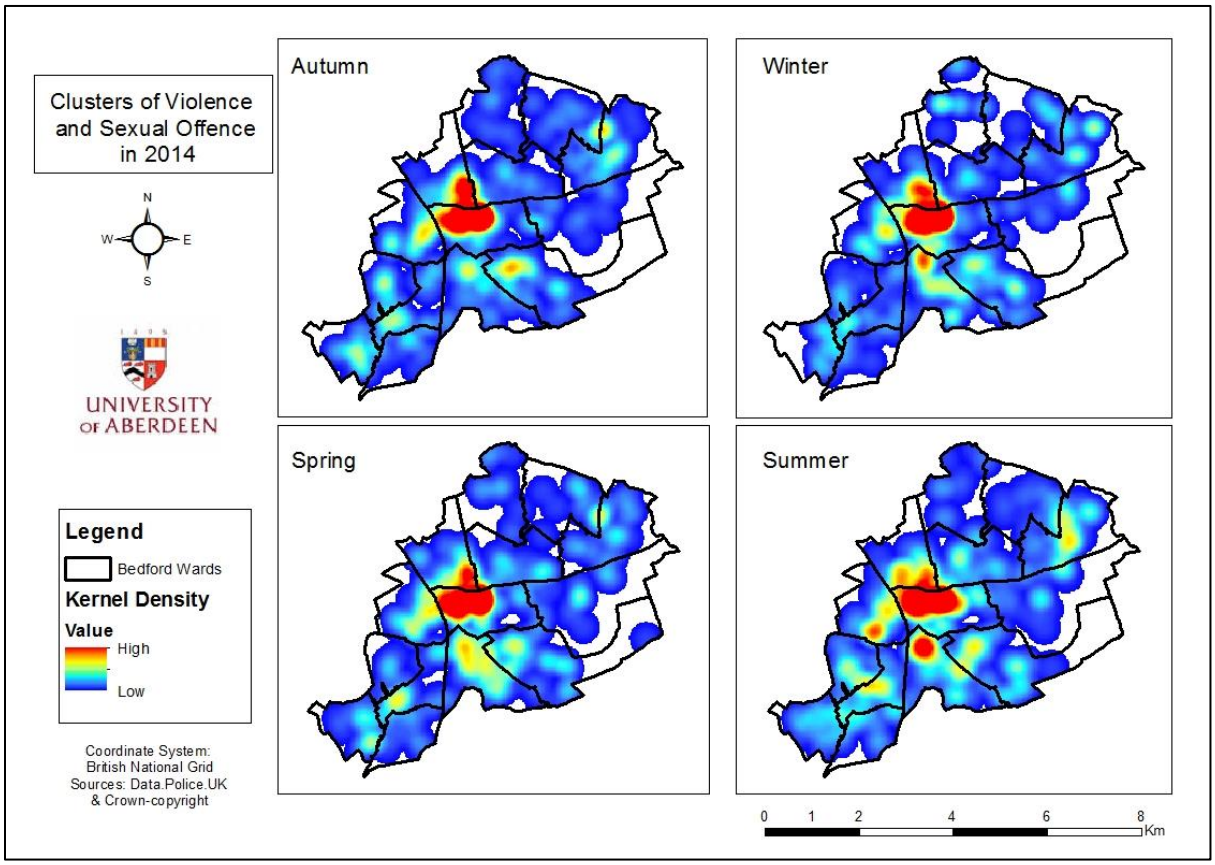


Figure 29: Clusters/hotspots for violence and sexual offences (seasons of 2014).

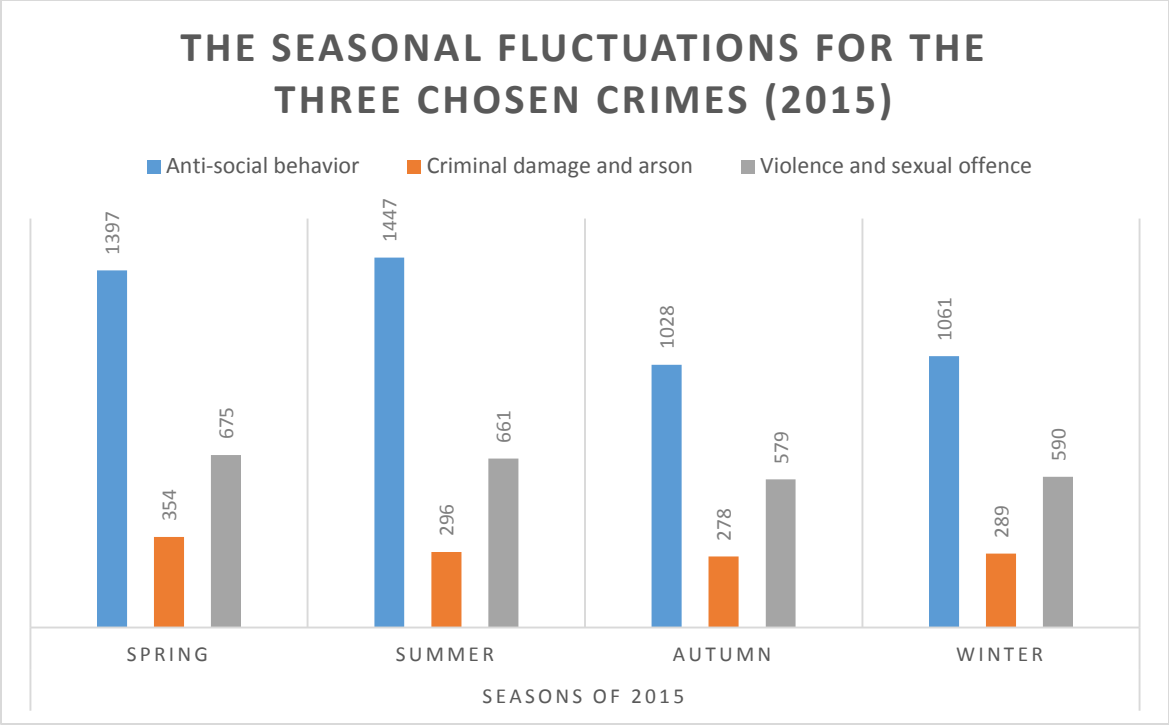
In contrast to the concentration of crime in autumn, incidence of violence and sexual offences was reported to extend from Castle and Harpur to Queens Park, Kingsbrook, Cauldwell, Putnoe and Kempston Central. In contrast, the concentration in these wards, and particularly in Queens Park and Cauldwell, increased during summer (Figure 29). For winter 2014, the concentration of violence and sexual offences appeared to occur within the boundaries of Castle, Harpur, De Parys and Cauldwell, with moderate concentrations in Kingsbrook and Queens Park.

Falk (1952) has highlighted that sexual crimes occur more frequently during the months of March and July. In fact, the number of sexual offences committed during summer is higher than in other seasons. Lauritsen et al. (2014) also contended that the rates for sexual assaults are highest during summer. It is also apparent from the cluster concentration shown on the maps that rates of violence and sexual offences were lower during winter and autumn, but that the spring rates were not significantly lower when compared with concentrations during summer (see Table 14 in the appendix).

During 2014, the major high-concentration clusters were more prevalent during summer and spring. The wards that reported higher concentration throughout the year include Castle (in first place) and Harpur (in second place), while the major seasonal fluctuations appeared in Cauldwell, De Parys, Queens Park, Putnoe and Kingsbrook.

Temporal Distribution of Crime in Year (2015)

According to the chart below, there was a prominent increase in antisocial behaviour in summer (1,447) and spring (1,397) in 2015. In winter the incidence of crime also increased to 1,061, while in the autumn it was 1,028 (Table 15 in the appendix). Thus, antisocial behaviour was highest in summer followed by spring, whereas the highest prevalence of violence and sexual offences shifted to spring from autumn. There was also a shift in criminal damage and arson, with the highest incidence in spring. Overall, for 2015, spring became the season of the highest incidence of the three crimes.



Temporal Distribution of Antisocial Behaviour Crime (2015)

In 2015, antisocial behaviour was noted as being widely scattered across the whole town compared to all seasons throughout 2013 and 2014 (Figure 30). During winter and spring of 2015, crimes of this type increased, while in autumn and summer there were no changes during this year. For autumn 2015, crime remained higher in Castle, Harpur and Cauldwell. In addition, Queens Park, De Parys, Kempston Wards, Putnoe and De Parys showed moderate crime distribution (Figure 30). As compared to autumn, crime seemed to expand in Cauldwell in winter, while it reduced in Putnoe, Queens Park and Kempston. The wards of highest concentration included Castle and Harpur. Compared to autumn and winter, crime increased in summer mainly in Cauldwell, Kempston Central and West, Putnoe and Goldington. Antisocial behaviour expanded in spring 2015 in Queens Park, Cauldwell and De Parys.

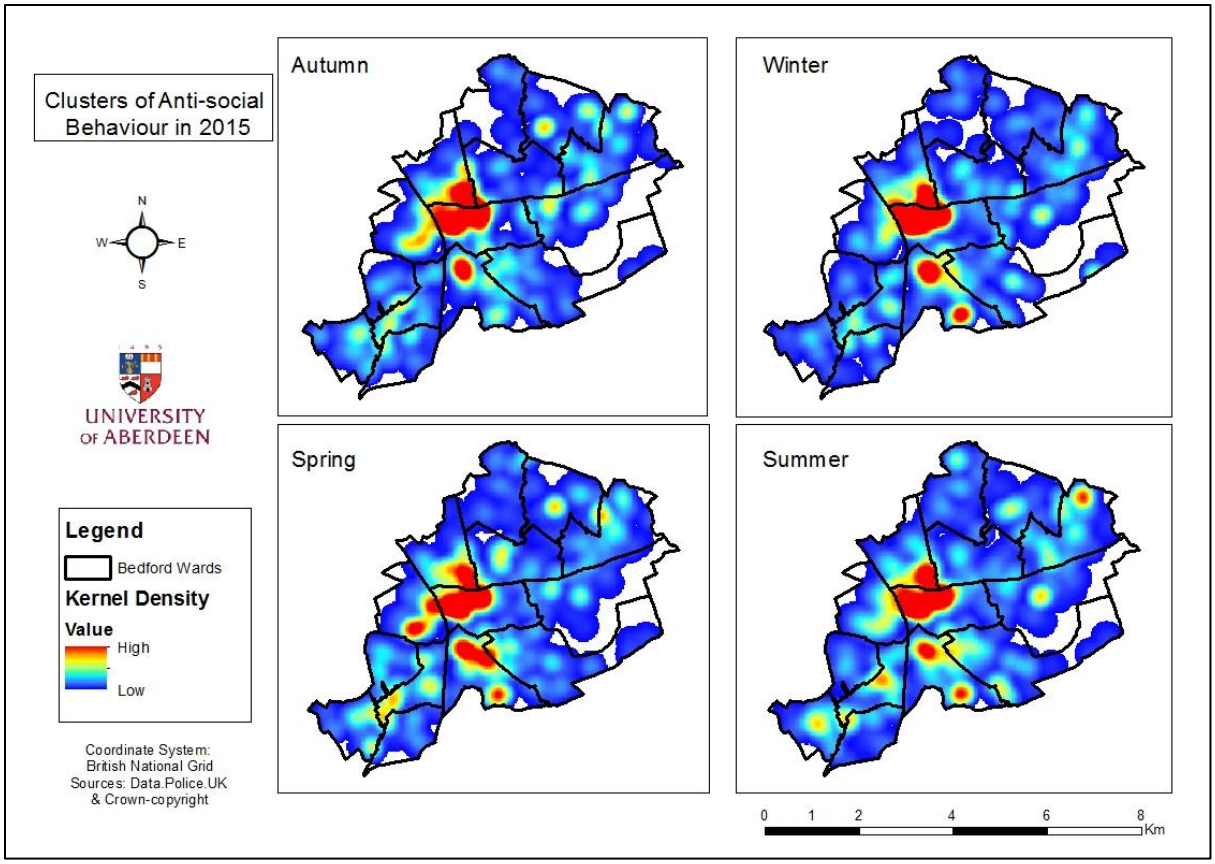


Figure 30: Clusters/hotspots for antisocial behaviour (seasons of 2015).

Temporal Distribution of Violence and Sexual Offences (2015)

Incidence of crime reported during 2015 showed slightly different concentrations for crime, and apparently violence and sexual offences extended to other areas as well. In autumn, concentration was more intense in the wards of Castle, Harpur, Queens Park, Kingsbrook, De Parys, Kempston Central, West and North, and Goldington (Figure 31).

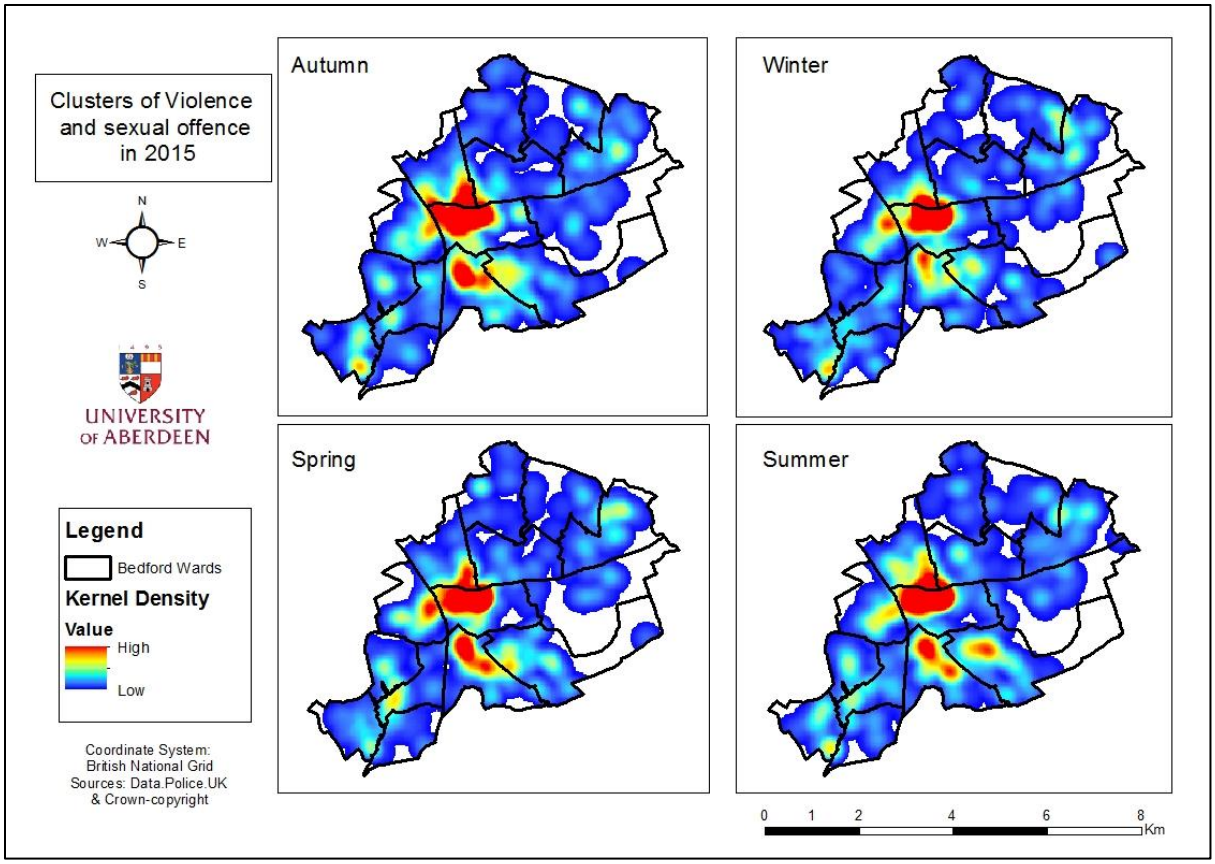


Figure 31: Clusters/hotspots for violence and sexual offences (seasons of 2015).

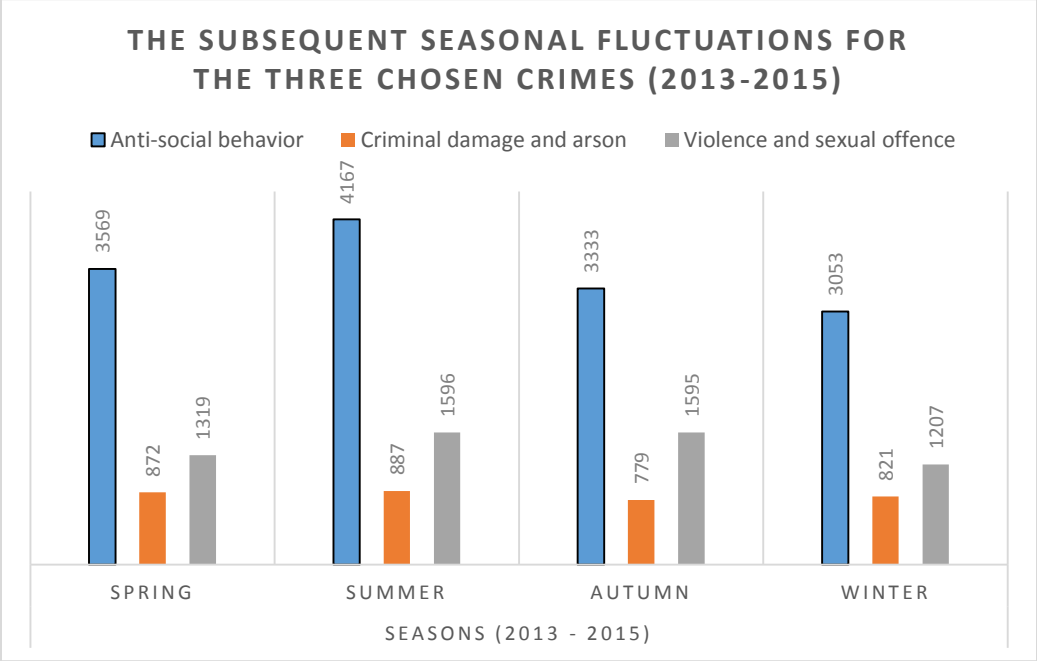
Crime reported during spring in 2015 showed only a slight difference from levels of crime reported in autumn (Figure 31). The results for difference in spring and autumn seasons are the reporting crime during autumn 2015 is slightly increased than those in 2014.

Reported crime for summer showed a prominent expansion of violence and sexual offences from Castle and Harpur to Kingsbrook, Cauldwell, Queens Park, Putnoe, Goldington and Kempston North, West and Central (Figure 31).

Results of Temporal Distribution for 2013–2015

Antisocial behaviour remained the prevalent crime throughout every season but was highest during summer, followed by spring. In general, during 2013–2015 antisocial behaviour showed a higher incidence during summer. Violence and sexual offences remained higher during summer and autumn, and criminal damage and arson was highest during summer. However,

criminal damage and arson had a comparatively static showing, with no stark differences by season.

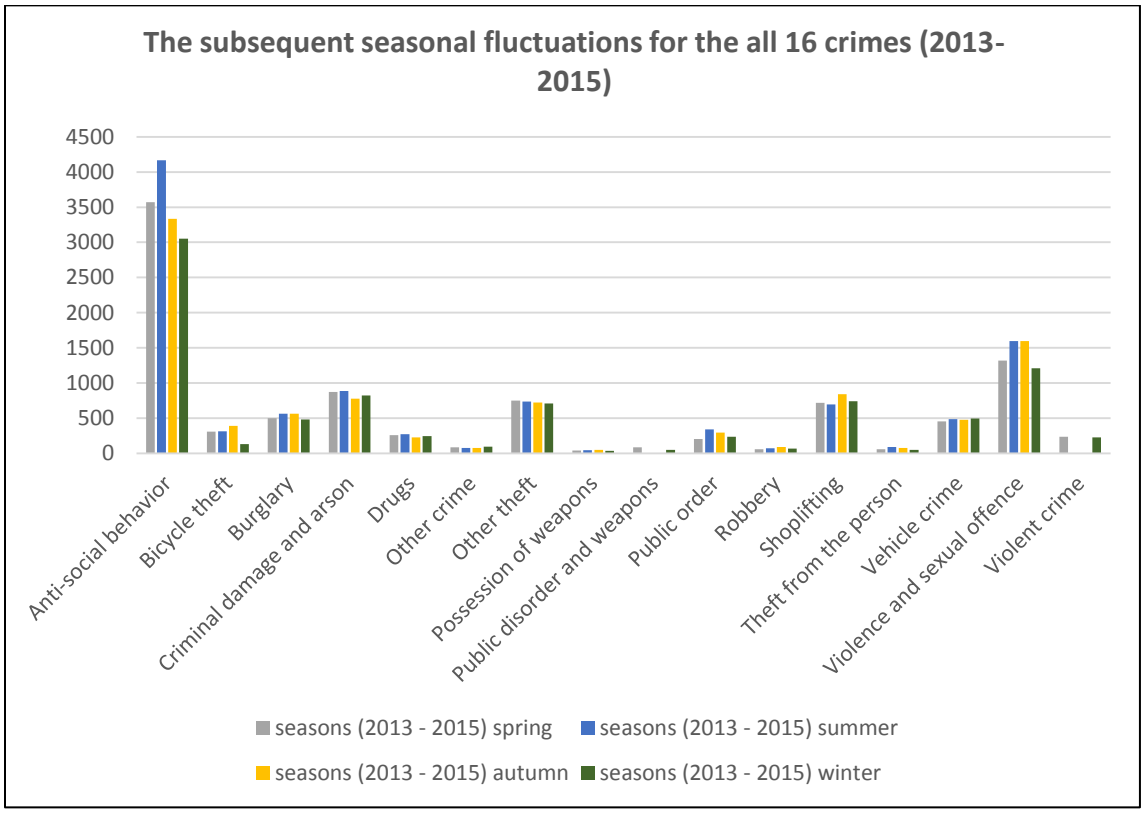


Temporal Distribution of Other Crimes

A number of studies have extended investigations for seasonal patterns in crime mapping within different contexts (Field, 1992; Farrell & Pease, 1994; Landau & Fridman, 1993; Cohn & Rotton, 2000; Rotton & Cohn, 2003; Ceccato, 2005; van Koppen & Jansen, 1999; Semmens et al., 2002; Uittenbogaard & Ceccato, 2012). All these studies have reported variation in the incidence and concentration of crime patterns on a seasonal basis as well as underlining the influence of geographical factors and type of crime on occurrence. It has also been established that geography can be used as a substitute to explain seasonal patterns, if not enough data is available. According to the findings, wards with low seasonal variations in climate exhibit only slight variations in patterns of crime.

A comprehensive overview of all 16 crimes and their seasonal fluctuations for 2013–2015 reveals that antisocial behaviour was the more persistent crime, with significantly higher

incidences in summer and spring (Table 16 in the appendix). Nevertheless, it remained prevalent throughout the year. Crimes with the lowest incidence were public disorder and weapons, possession of weapons, other crime, robbery, and theft from person. In addition, the crimes that occurred at an average rate included burglary, shoplifting and vehicle crime.



Overall, seasonality is the most common temporal pattern used to investigate crime. Criminal assaults are likely to increase during summer and subsequently decrease in seasons when outdoor activities are at a minimum (Anderson, 2015). Investigation of seasonal patterns is found to be of more significance, particularly in areas that report similar fluctuations in the rates of criminal assaults. Nevertheless, the variations in seasonal patterns depend on the type of crime and on investigation of seasonal patterns. These variations are important for areas that report recurrence of crime during certain periods of the year. Lauritsen et al. (2014) identified seasonal patterns as one of the most important topics for crime, as they enable the researcher to investigate

how change in temperature, environmental factors and daylight hours relates to the occurrence or exaggeration of crime throughout the year.

The way patterns of criminal assault change with respect to days of the week have briefly been described by Andersen (2014). According to the author, weekends remain the hotspots of highest crime concentration. One basic reason for this is provided by Grubesic and Pridemore (2011), according to whom violence and criminal assaults tend to occur on weekends because of increased alcohol sales. Newton and Hirschfield (2009) also affirmed the fact that violence against persons occurs more on weekends than on weekdays because of the peak timings for alcohol sales in the UK. The incidence of all the 16 identified crimes can therefore be related to day and night timings and in particular to days of the week.

Crime Reports with Respect to Area Population

According to the population distribution in Bedford wards, Kingsbrook and Cauldwell were identified as the areas with the highest levels of population in 2014 (Table 19 in the appendix). However, the crime rate in Kingsbrook was low compared with Castle and Cauldwell (Figures 32 and 33).

name	code	population
Kingsbrook	E360015	9460
Cauldwell	E360015	9305
Queens Park	E360015	8870
Castle	E360015	8620
Harpur	E360015	8425
Goldington Ward	E050087	8415
Kempston Central	E360015	8250
Brickhill	E360015	8165
Newnham	E360015	7775
De Parys	E360015	7065
Putnoe	E360015	6825
Kempston South	E360015	4355
Kempston West	E360015	3920
Kempston North	E360015	2960

Figure 32: Population density in Bedford for each ward (2014)

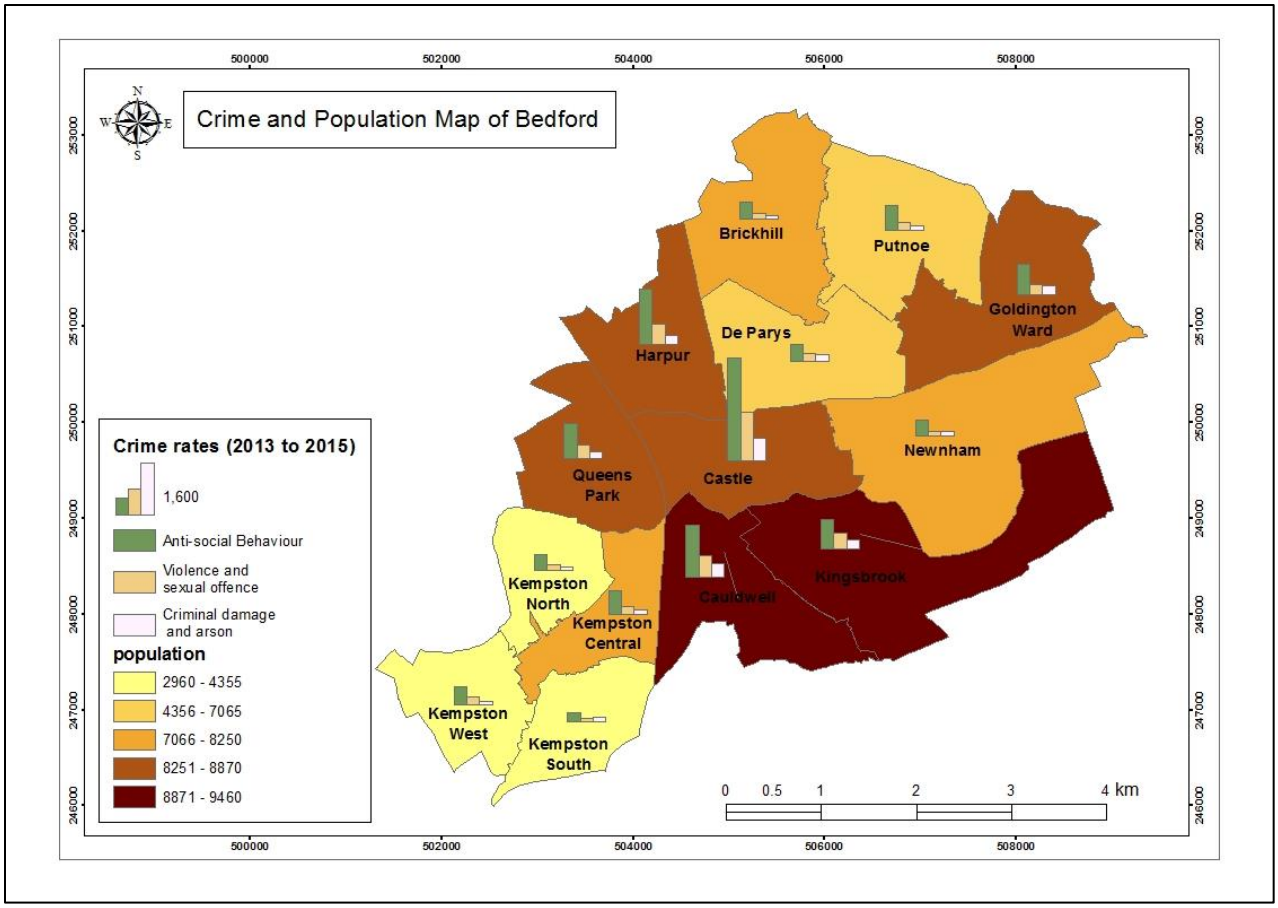


Figure 33: An overview of crime with respect to population for each ward in Bedford.

Figure 33 shows that the relationship between population and crime events non-significant and this was obvious in the wards of Kingsbrook and Queens Park. Crime analysis reveals that those wards have the highest population levels, but their levels of crime were moderate. On the other hand, wards that have moderate to high levels of population (i.e. Harpur, Castle and Cauldwell) experinced a high level of antisocial behaviour and violence and sexual offences.

Apparently, there is little linkage between the incidence of crime and population. Nolan (2004) related population size to criminal activity. According to Nolan, population size has little influence on crime events; furthermore, such areas provide greater opportunities for committing crimes and therefore remain the areas of higher concern for crime control agencies.

Chi-Square Test

Table 3 indicates the results of the chi-square statistical test. It is clear from the results that there were no significant differences in the distribution of frequency of crime according to area, season, gender or age. The probability values of all the selected variables were > 0.05. signifying that there were no differences in the distribution of crime frequency according to the variables mentioned.

Table 3: Chi-Square Test

Association	Chi-square	df	prob
Crime rate – area name	1386.00	1378	0.435
Crime rate – season	328.09	318	0.336
Crime rate – gender	108.00	106	0.428
Crime rate – age	332.00	318	0.283

The chi-square test was also applied to frequency of crime according to gender (Table 4). The results of the chi-square statistical test provided in the table below show that there were no significant differences for the distribution of frequency of crime according to gender. This is the case as the probability values related to chi-square were all > 0.05.

Table 4: Chi-Square Test for Gender

Gender	Chi-square	df	prob
Males	714.00	702	0.368
Females	700.00	689	0.377

However, when the chi-square test was applied to crime type according to year in the period 2013–2015, the results show that there were significant differences in the distribution of crime type in each year (2013, 2014, 2015) and the overall period (Table 5). This is the case as the probability values related to chi-square were all < 0.05.

Table 5: Chi-Square Test for Years

Year	Chi-square	df	prob
2013	1204.27	45	0.000
2014	185.84	39	0.000
2015	122.68	39	0.000
2013–2015	975.41	45	0.000

Multiple Regression Models

Frequency of crime in Bedford is supposed to be related to some known and recognized factors (variables). Therefore, four variables were selected (area, season, gender, age). To investigate the factors that may contribute to the total number of crimes, possible combinations of these factors were manipulated using linear regression analysis. The table below shows a summary of the results of the multiple regression models that have at least one factor contributing significantly to the total number of crimes.

Table 6: Summary of the significant multiple regression models.

Model	Influencing factors		R^2	Prob (f)	β	prob
1	Area, season	Area	8.7	0.007	- 13.08	0.326
		Season			151.69	0.002
2	Area, age	Area	7.5	0.014	- 10.46	0.434
		Age			138.11	0.005
3	Season, gender	Season	7.9	0.011	148.56	0.003
		Gender			8.93	0.934

4	Gender, age	Gender	7.0	0.019	16.89	0.876
		Age			138.11	0.005
5	Area, season, gender	Area	8.7	0.019	- 13.08	0.328
		Season			151.59	0.002*
		Gender			8.77	0.935
6	Age, area, season	Area	9.6	0.012	- 18.08	0.202
		Season			440.27	0.117
		Age			- 288.01	0.296

As can be figured out from the table above, it seems that the variable of season contributed in three different models (models 1, 2 and 5). Age contributed in two different models (models 2 and 4), while area contributed in one model only (6). The benefit of multiple regression models is expressed using different indicators, including R^2, the probability of f, beta (β) and the final probability. If the results have larger R^2 and greater f values, there is consequently less probability of f. Nearly the R^2 value in models (1, 2 and 5) was almost close and these models were statistically significant (all f probabilities were < 0.05). Model number 4 was the poorest in R^2 (7.0).

It can be seen from the above table that model 6 has the greatest R^2 (9.6) compared with the other models. In model 6, none of the factors (age, area or season) contributed significantly to the total number of crimes (based on the total number of crimes in each ward in Bedford). Therefore, although model 6 was statistically significant it will not be used anymore because it has a highly significant beta (β) >0.05.

Accordingly, and relying on this analysis of the summary table, it is clear that the most important factor affecting the total number of crimes in each area in Bedford was the season. Since the season was the factor that affected the number of crimes most, a simple linear regression model was utilized (Table 7).

Table 7: Simple linear regression model (model summary)

Model	R	R^2	Adjusted R^2	Std Error of the Estimate
1	.281[a]	.079	.071	564.18693

The value of R^2 represented in table 7 suggests a low value for the model of season affecting the number of crimes. However, the results in such cases would be acceptable, especially if this value was derived from one factor (season). The R^2 value reflects the fact that about 7.9 % of the variation in the number of crimes in Bedford wards could be attributed to season when crimes occur and the other factors explain the remaining percentage.

Table 8: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
	B	Std Error	β		
(Constant)	552.646	134.246		4.117	.000
season	148.658	48.418	.281	3.070	.003

Table 8 suggests that the impact value of season on crime numbers was 148.658. This value was considered to be statistically significant as the probability value related to the *t*-test was 0.003 (less than 0.05). Based on these figures and coefficients, a prediction model could be derived as follows:

Number of crimes = 552.646 + 148.658 (season β code)

Season codes were

1 for spring

2 for summer

3 for autumn

4 for winter

CHAPTER 5: CONCLUSION

This study has attempted to establish the credibility and efficiency of using GIS techniques in identifying the prevalence of crime. There is no doubt that social and geographic factors form the major basis for understanding the patterns of crime occurrence as well as the spatial and temporal distribution of crime. The study has provided an analysis of spatial and temporal crime distribution in Bedford. From the datasets provided by Bedford police, three of the most prevalent types of crimes have been chosen: antisocial behaviour, criminal damage and arson, and violence and sexual offences. Through applying GIS techniques, patterns of spatial and temporal distribution in Bedford have been uncovered.

Statistical methods are used in the present study, along with the spatial modelling of GIS for the police-generated crime reports and ONS data. The study emphasizes the comprehensive framework of tactical and strategic planning and how police forces take part in identification and investigation of areas with higher levels of crime. The study also used thematic maps for population analysis in Bedford.

The findings in the study reveal GIS to be capable of analysing crime patterns and to have more compatibility than traditional procedures. Identification and delineation of the hotspots for particular crimes can easily be traced with the help of maps. This not only helps researchers to understand the spatial and temporal distribution of crime but also the features related to demographic characteristics and area. In addition, the combination of SPSS, Excel and GIS has been proven to provide worthwhile results. It has helped to unravel the relationship between demographic characteristics, area characteristics and mapped crime factors for Bedford.

The study reports a strong relationship between season and area of crime. It is evident from the findings that criminal activity, in particular antisocial behaviour, violence and sexual offences,

and damage and arson, is at its peak during the summer season; however, there are also some crimes that do not increase or decrease with the seasons.

GIS can viably be applied after mapping out the temporal and spatial aspects of crime. GIS can be applied to identify not only crime hotspots on the maps and their spatial distribution, but also repetitive victimization. GIS has simplified the process of spatial analysis, which is highly elusive and impossible to carry out using traditional approaches. Similarly, creating lists of crimes is confusing and mostly results in misleading information since the collection of data relating to diverse hotspots is challenging (Chainey, et al., 2008).

Suggestions for Future Research

The present study has incorporated spatial and temporal analysis of the three main criminal events within the wards of Bedford. Since the study has been limited to three particular types of crimes that are reported to occur in the highest concentration in Bedford, the study has only established partial understanding of crime investigation and spatial mapping using GIS techniques. The investigation can be further extended to trace crime hotspots and fluctuations in frequency of crime with respect to area and socio-demographic factors, to create a predictive research model to facilitate GIS use in crime prevention and to predict vulnerable hotspots for crime.

In addition, the study has only relied on seasonal and yearly crime concentrations, while the temporal crime mapping can be modified to investigate weekly and daily crime patterns. Research has been conducted that has investigated crime patterns in relation to GIS techniques over seasonal patterns for areas other than Bedford (Andresen & Malleson 2013a; Andresen, 2009). The present research extended the previous findings by focusing on Bedford in particular. A study considering intra-week changes for spatial mapping would help to reveal the more intricate patterns of crime investigation, which could further be extended into a predictive model. Further

extension of the study in this way would help to identify spatial patterns in crime over different weekdays. This could be achieved through the use of GIS techniques. It would help researchers, policymakers, police forces and security authorities to monitor areas where crime is expected to occur. An increase in studies of the implementation of GIS techniques in crime mapping and investigation would not only contribute to the theoretical assets of research, but also, at a practical level, would help to deduce and apply situational analysis processes to make prevention initiatives successful. Assessment of gender for crime would also help to gain more precise results regarding criminal distribution.

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Appendix

Table 9: Monthly distribution of crimes in Bedford in 2013 (arranged descending).

	Crime / Months	1	2	3	4	5	6	7	8	9	10	11	12	total
1	Antisocial behaviour	480	362	388	376	317	353	551	467	354	339	320	274	4,581
2	Criminal damage and arson	92	96	76	79	86	99	97	98	61	96	86	97	1,063
3	Other theft	116	104	101	113	72	82	71	83	71	91	65	67	1,036
4	Violence and sexual offences	0*	0*	0*	0*	113	115	119	125	133	124	149	127	1,005
5	Shoplifting	49	76	89	70	69	53	71	69	61	81	94	82	864
6	Burglary	51	61	46	57	61	64	66	65	66	55	69	64	725
7	Vehicle crime	43	50	38	49	39	47	33	39	36	38	72	87	571
8	Violent crime	126	101	119	118	0	0	0	0	0	0	0	0	464
9	Drugs	15	22	18	34	29	36	32	28	21	25	27	37	324
10	Bicycle theft	0*	0*	0*	0*	61	26	36	49	37	37	46	13	305
11	Public order	0*	0*	0*	0*	17	22	26	37	39	18	21	19	199
12	Public disorder and weapons	25	24	47	36	0*	0*	0*	0*	0*	0*	0*	0*	132
13	Other crime	10	4	13	5	5	8	14	4	11	6	7	9	96
14	Theft from the person	0*	0*	0*	0*	10	18	12	7	8	13	14	9	91
15	Robbery	2	8	7	8	6	7	6	7	6	10	15	3	85
16	Possession of weapons	0	0	0	0	4	3	7	5	3	3	6	6	37
Total		1,009	908	942	945	889	933	1,141	1,083	907	936	991	894	11,578

*Crimes are not reported.

Table 10:) Monthly distribution of crimes in Bedford in 2014 (arranged descending).

	Crime / Months	1	2	3	4	5	6	7	8	9	10	11	12	total
1	Antisocial behaviour	281	255	345	348	398	451	483	415	441	468	383	340	4,608
2	Violence and sexual offences	152	156	179	168	184	205	199	172	176	236	198	182	2,207
3	Criminal damage and arson	79	68	87	95	95	84	103	110	85	90	83	100	1,079
4	Shoplifting	85	72	60	92	78	92	68	89	86	94	109	122	1,047
5	Other theft	68	62	86	79	73	85	98	62	106	81	80	77	957
6	Burglary	44	42	50	63	58	72	65	64	68	63	120	68	777
7	Vehicle crime	65	32	48	47	67	88	73	55	45	46	54	35	655
8	Bicycle theft	14	25	46	66	52	31	41	41	54	69	49	9	497
9	Public order	25	27	28	20	30	45	28	62	30	46	25	28	394
10	Drugs	44	30	25	21	28	34	28	40	29	31	24	27	361
11	Other crime	8	16	10	9	12	2	10	6	7	10	12	11	113
12	Theft from the person	3	3	9	12	11	12	7	13	6	6	9	10	101
13	Robbery	7	1	3	3	7	8	12	13	13	13	8	8	96
14	Possession of weapons	4	2	4	9	5	3	5	6	1	13	3	4	59
15	Public disorder and weapons*	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Violent crime*	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		879	791	980	1,032	1,098	1,212	1,220	1,148	1,147	1,266	1,157	1,021	12,951

*Two crimes, public disorder and weapons, and Violent crime, recorded (0) frequency.

Table 11: Monthly distribution of crimes in Bedford in 2015 (arranged descending).

	Crime / Months	1	2	3	4	5	6	7	8	9	10	11	12	total
1	Antisocial behaviour	315	374	413	489	495	490	480	477	372	343	313	372	4,933
2	Violence and sexual offences	171	184	215	228	232	242	230	189	174	207	198	235	2,505
3	Criminal damage and arson	100	94	110	118	126	106	100	90	95	102	81	95	1,217
4	Shoplifting	97	97	104	65	89	82	89	84	104	101	110	61	1,083
5	Other theft	65	69	87	78	62	77	92	86	77	75	76	80	924
6	Vehicle crime	62	57	69	50	47	50	46	53	55	72	60	63	684
7	Burglary	63	39	44	58	60	62	58	47	45	46	32	48	602
8	Public order	38	43	29	39	40	36	49	37	37	40	37	54	479
9	Bicycle theft	21	30	21	24	37	34	23	30	28	32	37	18	335
10	Drugs	22	26	44	32	25	14	35	26	23	28	17	20	312
11	Other crime	16	10	8	17	8	16	8	6	9	4	10	9	121
12	Robbery	13	12	9	9	8	4	8	8	8	9	9	11	108
13	Theft from the person	10	10	6	7	4	9	4	8	4	7	10	6	85
14	Possession of weapons	9	7	7	4	6	3	5	7	5	6	7	4	70
15	Public disorder and weapons*	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Violent crime*	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		1,002	1,052	1,166	1,218	1,239	1,225	1,227	1,148	1,036	1,072	997	1,076	13,458

*Two crimes, public disorder and weapons, and Violent crime, recorded (0) frequency.

Table 12: Yearly distribution of crimes in Bedford during the period 2013–2015 (arranged descending).

	Crime / Years	2013	2014	2015	total
1	Antisocial behaviour	4,581	4,608	4,933	14,122
2	Violence and sexual offences	1,005	2,207	2,505	5,717
3	Criminal damage and arson	1,063	1,079	1,217	3,359
4	Shoplifting	864	1,047	1,083	2,994
5	Other theft	1,036	957	924	2,917
6	Burglary	725	777	602	2,104
7	Vehicle crime	571	655	684	1,910
8	Bicycle theft	305	497	335	1,137
9	Public order	199	394	479	1,072
10	Drugs	324	361	312	997
11	Violent crime	464	0	0	464
12	Other crime	96	113	121	330
13	Robbery	85	96	108	289
14	Theft from the person	91	101	85	277
15	Possession of weapons	37	59	70	166
16	Public disorder and weapons	132	0	0	132
Total		11,578	12,951	13,458	37,987

Seasons Classification:

Spring = (March, April, and May)

Summer = (June, July, and August)

Autumn = (September, October, and November)

Winter = (December, January, and February)

Table 13: Crime types in Bedford listed according to season in 2013.

Crime Type	Seasons of 2013				Total
	spring	summer	autumn	winter	
Antisocial behaviour	1,081	1,371	1,013	1,116	4,581
Bicycle theft	61	111	120	13	305
Burglary	164	195	190	176	725
Criminal damage and arson	241	294	243	285	1,063
Drugs	81	96	73	74	324
Other crime	23	26	24	23	96
Other theft	286	236	227	287	1,036
Possession of weapons	4	15	12	6	37
Public disorder and weapons	83	0	0	49	132
Public order	17	85	78	19	199
Robbery	21	20	31	13	85
Shoplifting	228	193	236	207	864
Theft from the person	10	37	35	9	91
Vehicle crime	126	119	146	180	571
Violence and sexual offences	113	359	406	127	1,005
Violent crime	237	0	0	227	464
Total	2,776	3,157	2,834	2,811	11,578

Table 14: Incomplete – season totals in 2014.

Crime Type	Seasons of 2014				Total
	spring	summer	autumn	winter	
Antisocial behaviour	1,091	1,349	1,292	876	4,608
Bicycle theft	164	113	172	48	497
Burglary	171	201	251	154	777
Criminal damage and arson	277	297	258	247	1,079
Drugs	74	102	84	101	361
Other crime	31	18	29	35	113
Other theft	238	245	267	207	957
Possession of weapons	18	14	17	10	59
Public disorder and weapons	0	0	0	0	0
Public order	78	135	101	80	394
Robbery	13	33	34	16	96
Shoplifting	230	249	289	279	1,047
Theft from the person	32	32	21	16	101
Vehicle crime	162	216	145	132	655
Violence and sexual offences	531	576	610	490	2,207
Violent crime	0	0	0	0	0

Table 15: Incomplete – season totals in 2015.

Crime Type	Seasons of 2015				Total
	spring	summer	autumn	winter	
Antisocial behaviour	1,397	1,447	1,028	1,061	4,933
Bicycle theft	82	87	97	69	335
Burglary	162	167	123	150	602
Criminal damage and arson	354	296	278	289	1,217
Drugs	101	75	68	68	312
Other crime	33	30	23	35	121
Other theft	227	255	228	214	924
Possession of weapons	17	15	18	20	70
Public disorder and weapons	0	0	0	0	0
Public order	108	122	114	135	479
Robbery	26	20	26	36	108
Shoplifting	258	255	315	255	1,083
Theft from the person	17	21	21	26	85
Vehicle crime	166	149	187	182	684
Violence and sexual offences	675	661	579	590	2,505
Violent crime	0	0	0	0	0
Total	3,623	3,600	3,105	3,130	13,458

Table 16: Crime types in Bedford during the period 2013–2015 (Incomplete – season totals)

Crime Type	Seasons of 2013–2015				Total
	spring	summer	autumn	winter	
Antisocial behaviour	3,569	4,167	3,333	3,053	14,122
Bicycle theft	307	311	389	130	1,137
Burglary	497	563	564	480	2,104
Criminal damage and arson	872	887	779	821	3,359
Drugs	256	273	225	243	997
Other crime	87	74	76	93	330
Other theft	751	736	722	708	2,917
Possession of weapons	39	44	47	36	166
Public disorder and weapons	83	0	0	49	132
Public order	203	342	293	234	1,072
Robbery	60	73	91	65	289
Shoplifting	716	697	840	741	2,994
Theft from the person	59	90	77	51	277
Vehicle crime	454	484	478	494	1,910
Violence and sexual offences	1,319	1,596	1,595	1,207	5,717
Violent crime	237	0	0	227	464
Total	9,509	10,337	9,509	8,632	37,987

Table 17: Bedford's male population by area name and age.

Area/Male	(0–14)	(15–24)	(25–59)	(60+)
Brickhill	702	436	1,706	1,176
Castle	613	536	2,207	578
Cauldwell	1,150	683	2,636	587
De Parys	534	756	1,590	733
Goldington	1,117	558	1,878	777
Harpur	618	744	2,230	853
Kempston Central and East	698	414	1,748	710
Kempston North	355	255	842	364
Kempston South	421	245	910	398
Kempston West	579	337	1,187	445
Kingsbrook	1,115	569	2,285	695
Newnham	737	505	1,836	707
Putnoe	560	439	1,361	1,106
Queens Park	1,150	723	2,084	481

Table 18: Bedford's female population by area name and age.

Area/ Female	(0–14)	(15–24)	(25–59)	(60+)
Brickhill	620	369	1,793	1,363
Castle	559	581	1,793	749
Cauldwell	1,154	741	2,628	731
De Parys	377	650	1,430	994
Goldington	1,005	603	2,206	997
Harpur	529	609	1,809	1,033
Kempston Central and East	688	348	1,836	795
Kempston North	302	195	971	414
Kempston South	392	242	1,010	465
Kempston West	559	341	1,345	501
Kingsbrook	1,047	574	2,377	800
Newnham	730	522	1,926	812
Putnoe	530	354	1,492	1,283
Queens Park	1,172	596	2,055	608

Table 19: Bedford's male and female population according to area name and age.

Area/ Total	(0–14)	(15– 24)	(25–59)	(60+)
Brickhill	1,322	805	3,499	2,539
Castle	1,172	1,117	4,000	1,327
Cauldwell	2,304	1,424	5,264	1,318
De Parys	911	1,406	3,020	1,727
Goldington	2,122	1,161	4,084	1,774
Harpur	1,147	1,353	4,039	1,886
Kempston Central and East	1,386	762	3,584	1,505
Kempston North	657	450	1,813	778
Kempston South	813	487	1,920	863
Kempston West	1,138	678	2,532	946
Kingsbrook	2,162	1,143	4,662	1,495
Newnham	1,467	1,027	3,762	1,519
Putnoe	1,090	793	2,853	2,389
Queens Park	2,322	1,319	4,139	1,089